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ART. XI.—*Studies on the Transpiration of some Australian Plants, with Notes on the Structure of their Leaves.*

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(With Plates XIII.-XVIII., and Text Figs. 1-7.)

[Read 13th December, 1923.]

This work was commenced at the beginning of 1920 on the suggestion of Professor A. J. Ewart, and was made possible through the kindness of Professor J. Smyth in allowing me the time to prepare for, and carry out, the experiments in 1920.

So little work has been done on the transpiration of Australian plants, that I was glad to have the opportunity of attacking a branch of research work which opened up so many possibilities.

Moore, p. 207 (29) in 1899 wrote: "But we are told that the Australian flora stands less high in the scale and is less specialised than are the floras of northern climates; and, if this be true, the point I am trying to argue must at once be given up. But is it true? In what respect, it may be asked, is the flora of Australia less highly specialised. Are not most of the great natural orders strong constituents of it? Trees, some of them of gigantic size, shrubs, undershrubs, and herbs, parasites and saprophytes, climbing and carnivorous, flowers adapted to profit by the visits of insects, and sometimes provided with a complex mechanism to ensure such profit—all these are met with in Australia. In addition, we have wonderful adaptation to a dry climate, and in this respect, taking into account the variety of ways in which the destructive effects of a scorching sun and parched soil are guarded against, the Australian flora is without parallel the world over."

Ewart and Rees, p. 85 (15), wrote: "In at least one respect the Australian conditions as represented in the Melbourne district are comparatively unique, for, at certain times, hot dry winds blow from the interior and cause rapid rises of temperature up to 100° or even 120° F. The hot spell rarely lasts long and is usually followed by a cool change often accompanied by rain. The fall of temperature is usually more rapid than the rise. . . In neither case does the suddenness of the change appear to operate injuriously upon the vegetation, while its rapidity and irregular occurrence would be sufficient to prevent slowly responding plants specially adapting themselves to it. . . . . ."

Many other biologists have written in similar strain, and the outlook promised some surprises. My main object was to discover whether Australian plants have any special powers of accommodating themselves to adverse conditions, especially of regulating the transpiration rate when the temperature suddenly increases; hence. I considered it would be advisable to work with as many plants as I could handle, and to concentrate on the transpiration rates rather than to work with a few plants and deal more fully with their anatomy.

The work may be classified under the following heads:

(1) Preparation of laboratory.
(2) Preparation of plants and material.
(3) Estimation of transpiring areas.
(4) Estimation of the number of stomata per unit area, their distribution and measurement.
(5) Meteorological data.
(6) Illustrations: Photographs and micro-photographs.
(7) Transpiration experiments.
(8) Plants studied.
(9) Discussion on transpiration and the results of the experiments.
(10) Conclusions.

(1) Preparation of Laboratory.

As there was no room in or close to the Botany School where a large number of experiments could be carried on simultaneously, it was necessary to go further afield. Finally, it was decided to use the building in the system garden in the north-west corner of the University Grounds. The building consisted of a tower built of brick, with a glass house adjoining. The room in the tower was renovated and fitted with cupboards. The wide open space in front of the tower was admirably suited for outdoor experiments. In another part of the garden, a wire-netted enclosure had been constructed to protect experimental plots of cereals from birds, and this was used to prevent the plants from being interfered with. Meteorological instruments were housed in a properly constructed shed, which had been used by members of the Natural Philosophy School when making observations on the wet bulb thermometer.

I wish to thank Professor Laby for allowing me to transfer the building to the system garden and to use it in connection with the transpiration experiments. I fitted the shed with a rack and shelves so that it could be used for transpiration experiments on wet days and for observations in the shade. Arrangements were also made to accommodate the plants in the glass house if necessary.

(2) Preparation of Plants and Material.

At first I attempted to obtain a supply of plants by transplanting them from the bush, but without success. I then visited the Botanic Gardens, and explained my requirements to the Director, the late Mr. J. C. Cronin, and I have to thank him for a fine supply of plants and for the interest both he and his staff took in the work for which I was preparing. I also visited the Burnley Horticultural Gardens and received a kindly welcome from the late Mr. J. P. McLennan and his staff. All were keenly interested in the experiments and supplied me with any plants they had on hand. The specimens of *Ficus macrophylla* were obtained from the University garden and a number of seedlings of *Banksia serrata* were sent to me from Sale by my friend, Mr. H. J. Hauschildt, of the Sale Agricultural High School. In all, I collected one hundred plants. Of course, many of these were in duplicate. All plants were repotted into pots of three sizes (6 inch, 5 inch, and 4 inch) according to the type of plant, and what was considered would be its future requirements, especially in relation to the amount of water required during the transpiration experiments. The register number of the plant was written on the side of the pot with Brunswick black, and a label, with the same number, was attached to the plant.

I was unable to use two or three which were attacked by disease, and one or two which were broken by accident; but the rest thrived, and I had quite sufficient for my purpose; the number that I could use being limited by the number that could be weighed in a certain time. While the experiments were in progress, the plants were kept in the tower or in the glass house, but were transferred back to the open when not required. They were allowed to grow under conditions as normal as possible.

(3) Estimation of Transpiring Areas.

The method adopted in most cases was that of making a tracing of each leaf, either by placing the leaf on a sheet of white paper and drawing in the outline with a fine pencil, or of placing the leaf on a board, covering it with transparent paper and tracing the outline on the paper. The latter method was used with the leaves of *Grevillea robusta*. Areas were then found by means of Amsler's Polar Planimeter.

The foliage of numbers 13, 17, 19, 27, 34, 75, and 81 did not lend themselves to these methods; each required a special method which is described later.

I am much indebted to Professor Payne and Associate Professor Kernot, of the Engineering School, for assistance in obtaining specimens and for the use of apparatus.

(4) Estimation of the Number of Stomata per Unit Area, their Distribution and Measurement.

Removal of epidermis.—To enable counting to be done accurately, it was necessary to remove the whole of the epidermis intact. A number of methods for removing the epidermis was tried and finally the following was adopted: A fresh, green leaf was taken and, after cutting a thin slice off one margin, it was placed in a 15% solution of nitric acid in water, and boiled in a beaker until it could be seen that the epidermis was almost free from the tissues beneath.

It was necessary to watch the process the whole time and to manipulate the leaves with a glass rod to prevent them from adhering to the sides of the beaker. At first, the epidermis appeared to form the surfaces of blisters, but later, the epidermis of the upper and under surfaces would separate along the cut margin and open outwards.

The epidermis of the branchlets of *Casuarina Luehmanni*, of *Acacia juniperina*, and of the leaves of *Hakea gibbosa*, was removed by first making a slit along the whole length of the structure with a razor—along the ridge in *C. Luehmanni*, and between ridges in *A. juniperina*, and then treating in the acid solution as described above.

Much was learnt in this way about the relative strengths and thicknesses of the epidermis of both surfaces of the leaves; and how greatly the epidermis differs in different families and in species. A phyllode of *Acacia longifolia* was boiled for 30 minutes in a 25% solution of nitric acid and the epidermis was then still almost as tough as leather. The epidermis of the leaf of the adult *Eucalyptus alpina* was the most difficult to remove, while that of the seedling leaf of *E. maculata* var. *citriodora* required very careful handling as the epidermis of both sides is very thin. No definite time for boiling each type of leaf in the solution can be laid down; it is a matter for observation and judgment for each leaf. Leaves of adult Eucalypts and Acacias require from 10 to 15 minutes to clear the epidermis; while the leaves of *Prostanthera lasiantha* or *Oxylobium lineare* do not require a minute.

The material was then removed from the boiling solution, well washed with water and left for a day or two in a large amount of water.

The soft, disintegrated tissue was then easily removed from the epidermis by means of a forceps; and the inner surface of the epidermis cleared entirely by gently rubbing it under water with a seeker, a small swab of wadding or a camel's-hair brush.

Staining.—A water solution of gentian-violet gave good results and was used generally. The Acacias gave the best results with it, as, apparently, the tannic acid in the epidermis acted as a mordant and fixed the stain. They required only two or three minutes to stain, and, if left much longer, were overstained. The members of the Myrtaceae took much longer to stain than the Acacias, and did not stain so well The guard cells of the stomata usually stained very darkly.

After being stained, the material was placed in water until it could be examined, usually for not longer than two days.

Counting.—As the epidermis of both surfaces had been severed along one margin, they could be separated, opened out and placed side by side for examination. For the larger leaves a 3in. by 2in. glass slide, with cover-slip, was used. Long structures, like the phyllodia of *Acacia saligna*, were cut into large sections for examination.

The arrangement and massing of stomata could easily and quickly be examined over the whole surface with a low power objective. All the stomata on a leaf were not counted, but a large number of readings were made and the average taken. It was found that the best average was obtained by taking a series of readings midway between the midrib and the margin from apex to base. The number of stomata tends to increase from the margins to the midrib in the majority of cases. To assist in counting, grids, with different numbers of divisions, were introduced into the eyepiece as required. A microscope with No. 2 ocular and No. 7 objective was used in counting the stomata.

Measurements.—All measurements of stomata are given in micra. As all leaves were treated in the same way to remove the epidermis, very little variation was found in the condition of the pores, which were usually almost closed. Hence, it was considered advisable to measure only the length and breadth of the stomata outside the guard cells. The stomata were measured with a Leitz micrometer eyepiece and stage micrometer.

(5) Meteorological Data.

Temperature records were obtained by means of a thermograph which was housed in the meteorological shed, but, when only transpiration balance experiments were in progress, in the tower.

For all other meteorological data I am indebted to Mr. H. A. Hunt, Commonwealth Meteorologist, and his staff, who have always been ready and willing to assist me by supplying any information in their possession.

All meteorological data will be found set out in Tables II. and III., on pages 185 and 186 respectively.

(6) Illustrations.

Photography.—Having so many plants to deal with, photography was made use of at all stages to illustrate types, growth, structures, and apparatus.

Microphotographs of all stomata and of a few sections of leaves will be found on Plates XIV. to XVIII., in the order of, and under the register numbers of the plants to which they belong. Most of the microphotographs of stomata were taken with a magnification of 110 diameters, so that their sizes might be compared. On the figures in the plates where the magnification is not indicated, it should be taken as 110 diameters. In reproduction the originals have been reduced 50 per cent.

I owe a debt of gratitude to Professor Woodruff and to Dr. Seddon, of the Veterinary School, for allowing me to use the microphotographic apparatus, and for placing the room and materials at that school at my disposal, and to my brother, Mr. J. I. Wilson, for his help in making prints as required.

(7) Transpiration Experiments.

Two methods were used to obtain the records:

(1) The Transpiration Balance. Plate XIII., fig. 1.

(2) Direct weighing.

Most of the work was done by the second method, as the Transpiration Balance cannot be used in the open air, and only one plant at a time can be dealt with. As no apparatus, such as mentioned by Ganong, p. 45 (18), for preventing evaporation, was available, it was necessary to improvise a method; so, for the purpose, a number of empty cylindrical tins, 6in., 5in., and 4in. in diameter, were procured. When a pot was placed in a tin, the flange rested on the upper edge of the tin and the surface was sealed by means of one tin disc and two rubber cloth discs held in position by a strong rubber band. Plate XIII., fig. 1. With practice, the plants could be prepared for weighing at the rate of one per minute.

As the idea was to work with as any plants as possible, and, as it was desired to compare their activities under similar conditions, it was necessary to arrange for weighing all of them quickly. For this purpose, the plants were divided into three series according to the size of the pots. A fourth series was used in February, 1922, and experiments on evaporation from the free surface of water were done in conjunction with it. The series were arranged as follow:

Series A.—Plants Nos. 1 (3), **6**, 13, 14, 19, 27 (28), 33, 49, 59, 63, 67, 71, 81, **86**, **88**.

Series B.—Plants Nos. 26, 31, 34 (35), **40** (**41**), 50, 52 (53), 64, 68, 69, 78, (79), 83, 87.

Series C.—Plants Nos. (16) 17, 22, 29, 42 (43), 44 (45), 47, 53, 62, 66, 75.

Series D.—Plants Nos. 1, 14, 49, 82.

The number in brackets denotes a duplicate which was used at some time during the course of the experiments. Both in tables of records of weighings (Tables IV. to X.) and in the graphs to illustrate them (Figs. 1 to 7), the plants were kept in these series, except in the graphs, when Nos. 6, 86, and 88, of Series A were transferred to Series C, as the lines were too crowded in Series A; and No. 41 was transferred from Series B to Series C.

During the winter, this method of preventing evaporation from the pots was tested with dummies, both on the Transpiration Balance, and by direct weighing, and the loss by evaporation was negligible.

During the summer months similar experiments were also made, and it was found that there was a slight loss, which varied from hour to hour, the average loss per hour being from .2 to .5 gramme per pot.

On account of this, there will be a tendency for the transpiration results to vary slightly from the normal rate. All the weighings were carried out in the tower, and the plants, after being weighed, were placed outside on a low bench when the weather was fine, or in the meteorological shed on wet days, and for shade experiments.

All records with the Transpiration Balance were obtained in the tower. All calculations, as far as possible, were made with the slide-rule or with a calculating machine, for the use of which, I was indebted to the kindness of Professor Berry.

The transpiration experiments fall into four groups as regards time:

(a) July and August, 1920. (Winter.)
(b) December and January, 1920-1921. (Summer.)
(c) February, 1921.
(d) February, 1922.

A large number of weighings were made in July and August, to estimate the transpiration during the day in the shade, and at night. The weighings were made after periods of 3 to 6 hours.

The earlier weighings in the summer were made at intervals of from 3 to 6 hours in daylight; but, on special days, as many weighings as possible were made at hourly periods.

For purposes of comparison efforts were made to do weighings on consecutive days, and, as it happened, the results were unusual. For instance, on 23/12/20, the temperature rose to 108° F. at 2 p.m., and there was a pleasant breeze blowing from the east. On 24/12/20, the temperature rose as high as on the previous day, reached its maximum a little later, but there was a fierce north wind blowing for most of the day. It started some time before dawn and had reached 30 m.p.h. at 9 a.m., and gradually decreased towards sunset. (Table III., p. 186). Otherwise, conditions were practically the same for the two days. On 30/12/20 and 31/12/20, the conditions so far as the wind was concerned were reversed; but the temperature rose slightly higher on the second day. On 10/2/21 and 11/2/21, wind and temperature conditions were much the same, except that the temperature on the 11th lagged behind that of the 10th at 9 a.m. The plants were watered on the night of 9/2/21, but not again until the night of the 11th. The idea was to test for the wilting of the plants from insufficient supply of water, if possible.

As so many different types of plants were used, and their areas differed greatly, all weight records have been standardized, the standard being the "number of grammes of water transpired per sq. metre per hour."

(8) Plants Studied.

The following table gives a list of the plants which were used in the experiments. Each plant was allotted a register number and this number is used throughout, in preference to repeating the name, in the text, in tables, and in illustrations.

Twelve orders are represented by 32 species, and of these more than half belong to families found only in Australia, (Maiden, p. 163 (26)), and some of them are typical of special localities only, e.g., Nos. 67, 68, 13, etc.

INDEX TO PLANTS USED IN EXPERIMENTS.

Reg. No.	Name of Plant.	Date of planting.	Size of pot, in inches.	Gardens obtained from.
	Pittosporaceae			
1	*Pittosporum undulatum*	Aug., 1918	6	Botanic
3	,, *undulatum*	,, 1918	6	Burnley
	Sterculiaceae			
6	*Brachychiton populneum*	Aug., 1917	6	Burnley
	Casuarinaceae			
13	*Casuarina Luehmanni*	Aug., 1918	6	Botanic
	Urticaceae			
14	*Ficus macrophylla*	Aug., 1917	6	University
	Leguminosae			
16	*Acacia juniperina*	Aug., 1919	4	Botanic
17	,, *juniperina*	,, 1919	4	,,
19	,, *linearis*	,, 1918	6	,,
22	,, *montana*	,, 1919	4	Burnley
26	,, *pycnantha*	,, 1919	5	Botanic
27	,, *longifolia*	,, 1918	6	,,
28	,, *longifolia*	,, 1918	8	Botanic
29	,, *longfolia*	,, 1919	4	Burnley
31	,, *podalyrafolia*	,, 1919	5	Botanic
33	,, *saligna*	,, 1919	6	,,
34	,, *Baileyana*	,, 1918	6	,,
35	,, *Baileyana*	,, 1919	5	,,
40	*Oxylobium ellipticum*	,, 1918	5	,,
41	,, *ellipticum*	,, 1918	5	,,
42	,, *lineare*	,, 1918	4	,,
43	,, *lineare*	,, 1918	4	,,
44	*Pullenaea daphnoides*	,, 1918	4	,,
45	,, *daphnoides*	,, 1918	4	,,
	Thymeleaceae			
47	*Pimelea flava*	,, 1919	4	,,
	Myrtaceae			
49	*Eugenia Smithii*	Aug., 1918	6	Botanic
50	,, *myrtifolia*	,, 1918	5	Burnley
52	*Eucalyptus macrorrhyncha*	,, 1919	5	Botanic
53	,, *macrorrhyncha*	,, 1919	4	,,
59	,, *botryoides*	April, 1918	6	,,
62	,, *botryoides*	Aug., 1919	4	,,
63	,, *globulus*	,, 1918	6	Burnley
64	,, *globulus*	,, 1919	5	,,
66	,, *globulus*	,, 1919	4	,,
67	,, *alpina*	,, 1917	6	Botanic
68	,, *alpina*	,, 1919	5	,,

Reg. No.	Name of Plant.	Date of planting.	Size of pot, in inches.	Gardens obtained from.
69	,, *cladocalyx*	,, 1919	5	Burnley
71	,, *citriodora*	,, 1918	6	,,
75	*Leptospermum lanigerum*	,, 1919	4	Botanic
	Proteaceae			
78	*Grevillea robusta*	Aug., 1919	5	Burnley
79	,, *robusta*	,, 1919	4	,,
81	*Hakea gibbosa*	,, 1918	6	Botanic
82	*Banksia serrata*	,, 1919	4	Sale (in bush)
	Rubiaceae			
83	*Coprosma Baueri*	Aug., 1918	5	Burnley
	Labiatae			
86	*Prostanthera lasiantha*	Aug., 1918	6	Burnley
	Scrophulariaceae			
87	*Veronica Dieffenbachii*	Aug., 1918	5	Burnley
	Myoporaceae			
88	*Myoporum insulare*	Aug., 1918	6	Burnley

TABLE I.—AREAS OF FOLIAGE OF PLANTS USED IN EXPERIMENTS.

A.—Total area of foliage and stems or phyllodia in square cms.
B.—Total area with stomata—transpiring surface in square cms.

WINTER READINGS. SUMMER READINGS.

Reg. No.	Date.	A	B	Date.	B	Date.	B
1	29/7/20	267	267	24/12/20	356	6/1/21	338
1						4/2/22	596
3				29/12/20	324		
3				5/1/21	281	17/2/21	281
6	16/8/20	92	92	5/1/21	244	17/2/21	339
13	10/8/20	621	260	6/1/21	330	17/2/21	330
14	30/7/20	321	321	29/12/20	440		
14				6/1/21	423	17/2/21	462
14						4/2/22	656
17	11/8/20	329	329	6/1/21	1802	10/2/21	1538
19	26/7/20	336	672	29/12/20	956		
22	3/8/20	34	68	6/1/21	552	17/2/21	552
26	27/7/20	107	214	29/12/20	1031	17/2/21	880
27	23/7/20	903	1806	28/12/20	6646	17/2/21	5508
28				28/12/20	4515		
29	3/8/20	36	72	6/1/21	560	17/2/21	530
31	27/7/20	92	184	29/12/20	766		
33	27/7/20	154	308	10/1/21	1368	17/2/21	532
34						6/1/21	2042
35	11/8/20	192	384	29/12/20	580		
40	2/8/20	150	150	5/1/21	1291		
41				5/1/21	630		
42	3/8/20	40	80				
43				6/1/21	420		
44	2/8/20	61	61	6/1/21	71		
47	30/7/20	27	27	28/12/20	136		
49	30/7/20	282	282	29/12/20	530	17/2/21	530
49						4/2/22	611
50	2/8/20	111	111				
52	29/7/20	94	188	29/12/20	428	17/2/21	428
53	30/7/20	86	172			17/2/21	344
59	27/7/20	255	255	29/12/20	317	6/1/21	287
61	5/8/20	101	101				
62	5/8/20	44	44	5/1/21	115		
63	27/7/20	519	519				
64	29/7/20	211	211	29/12/20	706	17/2/21	706
65	4/8/20	103	103				
66	29/7/20	79	79	29/12/20	175	17/2/21	136
67	26/7/20	285	570				
68	27/2/20	60.5	121	29/12/20	418		
68	14/8/20	67	134				
69	30/7/20	68	68	29/12/20	176	17/2/21	194
71	27/7/20	178	355	29/12/20	618	17/2/21	618
75	30/7/20	33	66	5/1/21	317	17/2/21	364
75	12/8/20	38	76				
78	6/8/20	234	234	5/1/21	471	17/2/21	471
79	5/8/20	123	123				
81	10/8/20	481	481	7/1/21	1051		
82						4/2/22	123
83	3/8/20	320	320	29/12/20	412	17/2/21	247
83				5/1/21	331		
86	16/8/20	100	100	28/12/20	57		
87	16/8/20	262	262	28/12/20	164		
88	16/8/20	107	214	28/12/20	192		

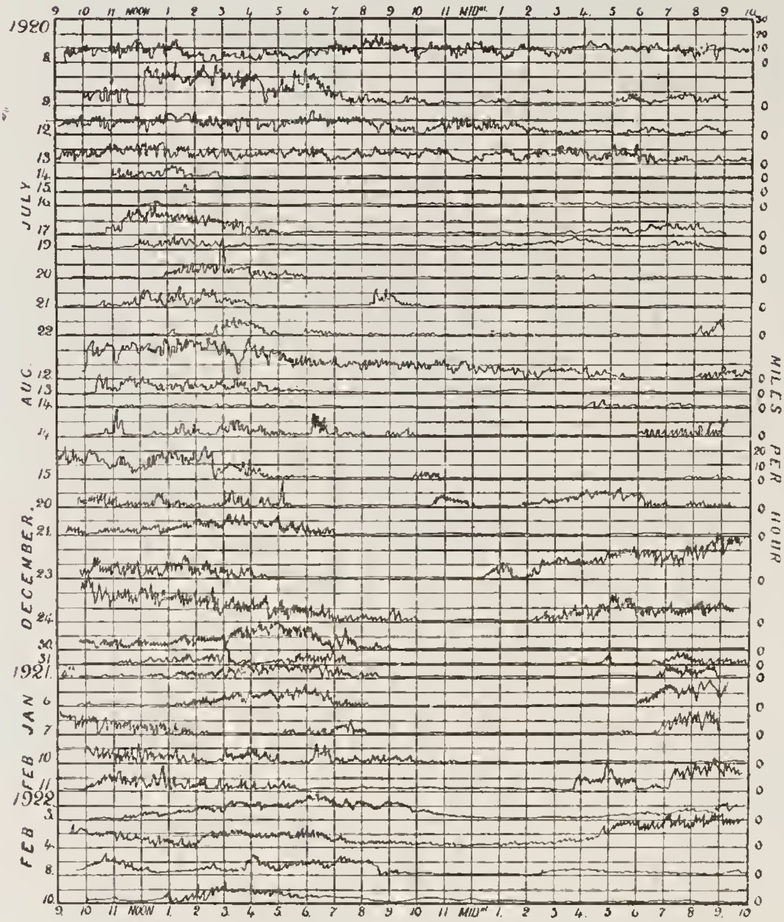
TABLE II.—TEMPERATURE RECORDS.

Thermometer Readings.

1920.		Solar.	Dry Bulb.			Wet Bulb.					%Humidity.		
		Max.	9 a.m.	3 p.m.	9 p.m.	Max.	Min.	9 a.m.	3 p.m.	9 p.m.	9 a.m.	3 p.m.	9 p.m.
J'ly	8	104.7	50.3	56.9	52.0	52.0	45.0	47.2	50.8	48.5	77.0	62	76.0
	9	102.3	53.4	59.1	49.2	53.4	46.3	50.6	52.3	46.0	81.0	60	77.0
	12	84.0	47.1	53.6	49.8	48.7	40.0	44.1	48.7	46.2	77.0	68	74.0
	13	65.5	47.1	53.8	48.5	47.6	42.8	44.1	47.5	44.0	77.0	58	66.0
	14	84.2	49.0	54.4	49.8	50.2	42.1	46.0	50.1	48.8	78.0	72	93.0
	15	82.9	46.0	54.0	43.4	49.8	42.7	45.0	49.5	43.1	92.0	70	96.0
	16	96.8	38.7	55.0	45.0	49.5	35.5	38.6	48.5	43.7	99.9	59	88.0
	19	105.9	44.1	59.1	43.4	53.0	37.3	42.8	51.0	42.0	90.0	54	88.0
	20	101.5	40.3	60.1	45.9	52.2	33.6	39.4	51.8	44.5	87.0	54	89.7
	21	73.2	47.9	54.2	45.6	51.0	38.5	47.1	50.4	45.4	93.0	75	94.0
	22	97.5	46.4	52.6	45.2	48.2	43.0	45.0	46.8	43.0	89.0	61	82.0
Aug.	12	101.9	47.5	54.8	48.0	49.3	40.0	44.3	48.4	46.4	76.0	64	85.0
	13	101.9	48.0	54.0	47.2	50.2	42.8	47.0	49.1	46.3	92.0	68	93.0
	14	102.0	47.0	53.9	43.0	48.5	40.2	45.9	47.8	42.8	91.0	60	98.0
Dec.	14	146.3	76.1	84.6	71.0	69.9	59.8	67.8	67.0	64.0	63.0	36	66.0
	15	135.8	74.9	74.6	63.2	63.4	59.1	60.2	61.8	59.0	38.0	44	77.0
	20	146.3	79.7	91.1	77.3	66.6	50.2	64.3	65.3	61.3	39.0	19	35.0
	21	141.3	74.2	73.1	61.0	68.0	56.4	63.5	65.6	61.5	52.0	65	86.0
	23	155.9	86.5	105.8	83.9	73.6	58.8	70.0	73.3	67.5	41.0	17	40.0
	24	154.2	93.9	105.1	90.5	73.5	63.8	69.7	73.2	66.9	25.0	17	24.0
	30	143.1	72.6	83.1	67.0	67.5	56.3	63.1	67.2	60.7	56.0	40	68.0
	31	144.5	78.7	86.3	77.4	73.0	57.1	66.8	69.0	68.0	51.0	38	60.0
1921.													
Jan.	4	135.0	64.9	77.5	66.8	63.5	48.1	56.7	63.0	61.2	56.0	40	71.0
	6	149.0	79.0	88.6	77.0	71.9	60.6	69.9	69.7	69.3	62.0	26	67.0
	7	149.4	81.4	92.1	81.5	73.8	62.0	69.6	71.0	71.0	53.0	32	57.0
Feb.	10	149.0	84.0	94.0	71.9	72.3	55.5	65.0	69.5	67.2	31.0	24	76.0
	11	152.0	77.8	97.3	77.8	72.1	62.3	68.5	70.9	71.2	60.0	23	71.0
1922.													
Feb.	3	128.9	65.0	79.8	66.4	65.2	48.1	55.2	62.8	60.0	50.0	34	66.0
	4	142.5	73.1	88.0	71.3	66.7	51.9	63.9	63.2	64.8	58.0	19	68.0
	8	112.1	75.7	71.7	65.5	67.2	56.8	64.3	66.2	59.5	51.0	73	68.0
	10	133.9	72.0	86.3	74.6	72.1	58.2	65.7	71.5	70.0	70.0	46	79.0

TABLE III.

ANEMO-BIAGRAPH RECORDS.



Nos. 1 and 3. Pittosporum undulatum (Sweet Pittosporum).

Description.—Maiden, vol. VII., p. 123 (28).

Epidermis.—It was fairly easy to remove, the upper being much tougher than the under. It did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are evenly distributed in the areas between the network of veins, except along the midrib and the larger veins, where they have a tendency to form in dense clusters. The highest number recorded was 450 per sq. mm. in one of these clusters. The average number was 320 per sq. mm. Twin stomata are of common occurrence and a pair can be seen on Plate XIV., No. 1. The average size is 24 x 19 micra, but there is a small percentage 29 x 23 micra.

The subsidiary cells have the long axes parallel to that of the pore and usually number two, seldom more. In these specimens, neither the guard cells nor the subsidiary cells stained well. The walls of the subsidiary cells are much thinner than those of the epidermal cells. Plate XIV., No. 1, Table XI., p. 225.

Glands and Hairs.— Absent.

Transpiration Experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225; Figs. 1 and 2, pp. 196 and 198.

The sudden rises of temperature shown on the mornings of the 23rd, 24th, and 26th, were due to the blind being raised on the east window, so that the sun shone directly on to the plant and the recording thermometer. The shade temperature reached its maximum in the tower at 2 p.m. each day, and the temperature curve shows that the maximum was reached between 2 and 3 p.m., except on the days when the sun was allowed to shine directly on the plant. Fig. 2, p. 198.

On 23/12/20, the younger leaves began to wilt at 10.45 a.m., and the transpiration rate fell; but at 2 p.m., water was added and towards 5 p.m. the plant recovered and the transpiration rate rose slightly. On 24/12/20, the highest record was 217. The young leaves were wilting at 2.10 p.m., so the plant was placed in the tower, watered, and it recovered in about 20 minutes. The shade temperature was then 104° F., and the water in the tin vessel was 108° F. Wind does not appear to affect the transpiration rate of this plant, and the high temperature did not make the old leaves wilt.

No. 6. BRACHYCHITON POPULNEUM (Kurrajong).

Description.—Maiden, VII., p. 77 (28).

Epidermis.—It is not very thick and on the under side is thinner than that on the upper side. The fact that the veins are so closely associated with the lower epidermis made it much more difficult to clear it from the underlying tissue. The cell walls did not stain well except in those cells outlining the strands.

Area.—See Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are regularly arranged in the areas bounded by the thicker-walled cells of the cuticle where it is attached to the strands. As in the leaf of No. 1, a fair portion of the area on the under side is taken up by these chains of cells which have no stomata. The highest number noted was 420 per sq. mm., the average being 310 per sq. mm. They do not vary much in size, but there are usually from 8 to 20% of a larger type. The usual size is 21 x 18 micra, the larger size being 31 x 26 micra. Plate XIV., No. 6, Table XI., p. 225.

The subsidiary cells are thin-walled and usually number only two, and their long axes are parallel with that of the pore.

Glands and Hairs.—Absent.

Transpiration Experiments.—Tables IV., V., and XI., pp. 194, 195, and 225; Fig. 6, p. 215.

On 24/12/20, the highest record was 219, so that the strong wind caused a decline in the transpiration rate. On 10/2/21, the younger leaves began to wilt at 2.45 p.m., and the next day the larger leaves showed light yellow patches.

No. 13. Casuarina Luehmanni (Buloke).

Description.—Maiden, Vol. II., p. 86 (28); Baker, p. 608 (3).

For an account of the anatomy of the Casuarinaceāe see Solereder (40), Boodle and Worsdell (6), and Goeppert (19).

These trees are often found growing in large numbers over restricted areas on low-lying ground adjacent to sand hills. In rainy seasons, the ground in which they are living is water-logged for some time, but in dry seasons it becomes hard and cracked. The tree is shallow-rooted and, as a rule, the tap root divides before any great depth is reached. The lateral roots grow to great length, but do not increase in diameter much above an inch. Under the trees, the ground is matted with the fallen branchlets and the characteristic small disc-like fruits. The green wood is easily cut with an axe, but, when dry, it is one of the hardest of timbers. The main cracks appear along the medullary rays and very few are annular.

The *structure* of the branchlets agrees in the main with that of other members of the order. hut, in this species, the branchlets are thicker and much more wiry. These characters tend to make each branchlet stand out more strongly by itself. There is less drooping and clustering of branchlets than in other species.

As a result of the reduction of the foliar organs, the young branches and branchlets are the chief assimilating organs of the plant. This function is carried on by means of an abundant supply of palisade parenchyma which is developed in the cortex of the young branch.

Leaves are really present but they are reduced to small teeth which form whorls at the node. The *branchlets* are formed of a series of internodes or joints, each of which forms a sheath at its upper end, and encloses the base of the internode above it. It terminates in from 7 to 10 teeth. The average of 101 readings for the specimen worked with was 8 on the branchlets and 10 on the larger branches.

Observations on the branchlets of three other species gave the following results:

C. Cunninghami, 5 teeth.
C. suberosa, 5 teeth.
C. Huegeliana, 9 to 10 teeth.

The *diameter* of the internodes of No. 13 varied from 1.5 to 1.75 mm., and the length from 7.5 to 10 mm.

Ridges.—The ridges or ribs which run the length of the internode are well defined and the corresponding grooves or furrows between them are plainly outlined. The ridges which have an average width of .40 mm. are covered with an epidermis consisting mainly of small, narrow, elongated cells with a very thick cuticle in which are embedded the characteristic roundish, doubly-refracted bodies which, according to Solereder (40) are not oxalate of lime. The lateral walls of the elongated epidermal cells are thickened and pitted. Extending from end to end of the internode down the middle of each ridge is a narrow band of epidermal cells which are almost square in outline, and have very much thicker walls than the remainder of the cells covering the ridge. Plate XIV., No. 13 (a). The width of a ridge remains fairly uniform whatever the number forming the branchlet. On the larger branches, the average number of ridges is 10, and their width, .48 mm.—slightly more than on the smaller branches; but the grooves are not quite so deep, being .26 mm.

Grooves or furrows.—The walls of the furrows consist of 4 or 5 longitudinal rows of elongated cells, rectangular in outline, the walls of which are much thinner than those of the cells along the ridge and are not pitted. The height of the walls varies slightly: one averaging .16 mm. and the other .14 mm. The bottom of the groove consists of 3 or 4 rows of exceedingly narrow, much elongated, and very thick-walled cells, from which springs a closely packed line of hairs or trichomes. These seem to completely fill the groove and to extend somewhat above the walls, giving the furrows a hairy appearance when viewed from above.

Hairs.—These are of two kinds. Plate XIV., Nos. 13 and 13 (c).

(a) Simple trichomes consisting of two short comparatively thin-walled superposed basal cells supporting a longer terminal cell with thick walls.

(b) Branched trichomes consisting of two short and comparatively thin-walled superposed basal cells, supporting two long thick-walled cells, dichotomously inserted in the upper basal cell and forming an acute angle with each other. The dichotomous branching is often repeated in one or both of the branches. This description corresponds to that given by Poisson for the trichomes in *C. equisetifolia* var. *incarna.* Solereder, p. 787 (40). The hairs prevent dust and moisture from entering the furrows.

Area.—The measurements of the ridges and furrows were taken from a transverse section of an internode. Plate XIV., No. 13.

In this, the ridges stand out boldly and springing from the bottom of the furrows between them can be seen the trichomes, the tops of which bend over on to the ridges. The following method of measuring the area of the ridges and furrows and for examining the walls of the furrows was also adopted: the epidermis of an internode was slit with a razor longitudinally and then treated as described for removing the epidermis of leaves. The epidermis was removed and the whole flattened out on a glass slide. This enabled the width of the ridges and furrows to be checked, and the walls of the furrows, and the hairs to be examined quite easily. The cell walls did not stain well with gentian-violet; but better results were obtained with Bismarck brown. The measurement of the area was arrived at as follows: From previous measurements of ridges and grooves the total circumference could be calculated, the total width of a ridge and the walls of a groove being .7 mm. Taking the average of 8 ridges to a branchlet, the total circumference would be 5.60 mm. Plate XIV., No. 13 (a).

The *length* of the branchlets was calculated by laying the plants flat on a sheet of cartridge paper, marking out the branches to the ends of the branchlets, and then drawing lines to represent these.

Chlorophyll containing tissue is restricted to the ridges and consists of three layers of radially elongated cells. This is shown on Plate XIV., No. 13, as two dark masses, one on each side of the ridge, but almost meeting in the middle. The remainder of the ridge consists of sclerenchymatous fibres elongated in longitudinal direction, and this extends to the outer limit of the cortical vascular bundle. There is no hypodermal parenchyma immediately beneath the epidermis as figured by Solereder, p. 778, Fig. 186 (40), for *C. equisetifolia*, also the amount of sclerenchymatous fibres in relation to the palisade parenchyma is greater in the ridges of *C. Luehmanni*. The circle of vascular bundles of the central cylinder can be plainly seen, and outside this circle the cortical vascular bundles may also be seen. A greater amount of sclerenchymatous tissue is present with the vascular bundles of *C. Luehmanni*, than is shown for *C. equisetifolia*. Apparently the strong wiry character of the branchlets is due to the specially thickened cell walls of the epidermis, and to the increased amount of sclerenchymatous fibre forming the ridges and associated with the vascular bundles.

On 10/8/20, the length of the branchlets totalled 1000 cm., and the branches 68cm., giving a total area of 621 sq. cm. As there are no stomata on the ridges, but only on the walls of the furrows, the transpiring area would be $1000 \times .24 + 68 \times .30$ cm. = 260 sq. cm.

The average number of ridges on the branches was 10, hence, the width of the stomatal area of an internode would equal .30 cm.

On 6/1/21, the transpiring area had increased to 330 sq. cm. by new growth. It increased somewhat more up to 17/2/21, but an equal amount of material was removed for examination, hence, the area is shown as the same on the two dates. Table I., p. 184.

Stomata.—These are found only on the walls of the furrows, on which they are arranged usually in four rows; but sometimes there may be only three rows on one side or the fourth row may have very few stomata in it. The stomata are placed at right angles to the direction of the furrow, and each is provided with two subsidiary cells lying with their long axes parallel with that of the pore. Plate XIV., Nos. 13 (a) and 13 (b). They are very uniform in size, the average being 31 x 18 micra. The length of the pore is very small compared with the length of the guard cells, being less than one-third of their length; and the junctions of the guard cells are strengthened.

The stomata are packed so closely together, that there are seldom two epidermal cells between pairs of them.

The following readings give the number of stomata per .35 mm. of the epidermis in the furrow:

Wall of Groove	11	9	—	—	11	8	11	11	1	11	10	9	10	10	10
	9	8	10	10	7	7	8	9	9	9	8	9	8	9	6
	4	8	10	1	7	11	8	9	9	5	8	7	8	8	10
*	3	1	7	6	9	10	10	4	10	7	9	8	10	13	8
Wall of Groove	9	8	7	9	6	8	10	11	11	10	9	13	8	10	7
	9	9	8	7	9	6	—	10	3	11	6	—	4	—	8
	—	4	—	—	—	—	—	—	—	—	—	—	—	—	2
Tot. per .35mm.	45	47	42	33	49	50	47	54	43	53	50	46	48	50	51

* = The strand along the base of the furrows to which the hairs are attached.

The average number per sq. mm. of transpiring surface was taken as 500.

Glands.—Absent.

Transpiration Experiments.—See Tables IV., V., and XI., pp. 194. 195, and 225; Fig. 1, p. 184.

No. 14. Ficus macrophylla (Moreton Bay Fig Tree).

Description.—Maiden, Vol. I., p. 8 (28); Bentham, Vol. VI., p. 170 (4).

Epidermis.—The epidermis was easily removed. Though that on the under side of the leaf is much thinner than that on the upper, it is relatively thick. It stained fairly well.

Area.—See Table I., p. 184.

Stomata.—There are no stomata on the upper surface. On the under surface, they are fairly evenly distributed over the whole of the leaf within the network of thicker-walled cells which outline the veins in contact with the epidermis. There is a very slight tendency for the number to increase along the main veins. The highest number recorded was 170 per sq. mm., the average number being 120 per sq. mm.

The size varies very little, the average being 31 x 21 micra. The subsidiary cells are narrow, and the long axes are parallel to that of the pore. Plate XIV., No. 14, Table XI., p. 225.

Hairs and Glands are absent.

Transpiration experiments.—See Tables IV., V., X., and XI. pp.194, 195, 220, and 225; Figs. 1 and 7, pp. 196 and 221.

No. 17. Acacia juniperina (Juniper Acacia).

Description.—Bentham, Vol. II., p. 331 (4).

In the specimens used the phyllodia were for the most part arranged roughly in whorls. In transverse section they are diamond-shaped, and at each angle is a narrow band of elongated epidermal cells, rectangular in outline, and with greatly thickened and pitted walls. A few of these can be seen on the lower side of the illustration on Plate XIV., No. 17.

Epidermis.—This was removed similarly to that of No. 13. It stained well with gentian-violet.

Area.—This was found in the same manner as that of the branchlets of No. 13. The area of a spine 9.4 mm. long was 12.54 sq. mm.

The length of the phyllodia varied from 4 mm. to 11 mm. Only a few were 11 mm., and the average of a large number of readings was 7 mm.

The area of the average phyllode was .09 sq. cm. Table I., p. 184.

Stomata.- They are very regularly and evenly arranged on each of the four faces of the phyllodia, as shown by the numbers counted on a phyllode 9.4 mm. long, which had been slit down one face.

The numbers on each face were 613, 636, 593, 574, making a grand total of 2416 stomata per phyllode. The average number for a phyllode 7 mm. long was taken as 1800, and the number per sq. mm. as 192.

On the stem there are longitudinal ribs or ridges similar to those on the phyllodia, but wider and stronger. The stomata are arranged on the sides of the ridges, leaving the area in the middle clear. There were 10 ridges on the main stem, and an average of 8 on the smaller branches; and there was an average of 290 stomata per sq. cm. of ridge.

They are uniform in size, but fairly small, being 23 x 18 micra; and are arranged with the long axis parallel to the long axis of the phyllode. The subsidiary cells are two in number, with the long axis parallel to the long axis of the pore. Plate XIV., No. 17. Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VIII., IX. and XI. pp. 214, 216, and 225; Fig. 6, p. 215. On 24/12/20, the plant was blown over, so no records were made before 11 a.m.

No. 19. Acacia linearis (Narrow-leaf Acacia).

Description.—Bentham, Vol. II., p. 399 (4').

The phyllodia are not rigid, but rather pliable and sway about easily in the slightest breeze.

Epidermis.—Is thick and tough, but was easily removed.

Area.—This was found by taking 19 types from the plant, and fitting every phyllode to one of them. Table I., p.

Stomata.—They are arranged very evenly on both sides and are uniform in size. There is a slight tendency for the number to increase from the base to the apex, as shown by the average of a number of records per sq. mm.

	Apex	Middle	Base
(a) side ..	199 ..	178 ..	165
(b) side ..	203 ..	182 ..	168

The highest number recorded per sq. mm. was 230, the average number being 183 per sq. mm. The stomata are arranged with the long axis parallel to the long axis of the phyllode and usually parallel to each other.

Very little of the area is taken up with the strands which are few and narrow. The number of stomata near the strands is slightly greater than at a distance. They have a uniform size of 36 x 16 micra; and the subsidiary cells are two in number, with the long axes lying parallel to that of the pore. They did not stain so deeply as the other epidermal cells. Plate XIV., No. 19, Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225; Fig. 1, p. 196.

No. 22. Acacia montana (Mountain Acacia).

Description.—Bentham, Vol. II., p. 367 (4); F. v. M. (34).

Epidermis.—The phyllodia are very thin, and the epidermis is quite brittle to handle after being removed. The vertical walls of the cells are sinuate.

Area.—This was found by making tracings of each phyllode. Table I., p. 184.

Stomata are arranged evenly on both sides of the phyllode. There is very little tendency to crowd together even at the base. The long axes of the pores are not arranged parallel to one another. The highest number recorded per sq. mm. was 150, the average being 100 per sq. mm. for both sides. They vary very little in size, the average being 23 x 18 micra. A few larger ones, measuring 31 x 26 micra were noted. The guard cells are relatively large, and the pores small for the size of the stomata. The subsidiary cells are two in number, large, and the long axes lie parallel to that of the pore. Plate XIV., No. 22; Table XI., p. 225.

Glands.—These are numerous on both sides of the phyllode, the average number being 6 or 7 per sq. mm.

Hairs.—A few simple hairs are found along the central strand on both sides of the phyllode, and also along the edges.

Transpiration experiments.—See Tables VIII., IX., and IX.; pp. 214, 216, and 225; Figs. 6, p. 215.

No. 26. Acacia pycnantha (Golden Wattle).

Description.—Maiden, Vol. III., p. 137 (28); F. v. M. (33); Bentham, Vol. II., p. 365 (4).

Epidermis.—Thick, tough, and easily removed. It stained well with gentian-violet, except the subsidiary cells of the stomata.

Area.—Table I., p. 184.

Stomata.—The stomata are arranged regularly on both sides of the phyllode, but the long axes of the pores are not parellel to one another. The highest number recorded was 190 per sq. mm., the average for both sides being 146 per sq. mm. There is very little variation in the size, the average being 31 x 21 micra. The subsidiary cells are two in number, large, and the long axes are parallel to that of the pore.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205. On 10/2/21, the young phyllodia soon wilted, and parts of two began to turn yellow. Three very young ones at the apex were scorched and dropped off.

TABLE IV.—TRANSPIRATION RECORDS.

SERIES A. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour

1920. JULY	TIME FROM	NO. OF HOURS.	Register Numbers of Plants. 1 3	13	14	19	27 28	49	59	67	71	81	86
8	10-35	5.00	34	54	24	40	31	32	101	37	31	37	37
9	11-00	5.25	18	22	31	18	22	61	82	35	27	36	—
19	11-00	5.20	32	63	18	36	35	22	97	47	38	28	—
20	9-40	6.70	29	52	35	37	38	27	82	38	31	30	—
AUG.													
13	9-55	6.50	59	44	40	37	39	32	75	44	32	43	32
14	10-18	6.00	27	35	33	34	34	32	37	30	28	38	71
JULY.									DAY.		IN SHADE.		
15	12-30	4.50	0	0	10	4	4.5	8.5	6.6	15	1.7	14	—
21	9-30	24.0	0.8	0.7	1.9	1.8	1.8	2.2	6.3	1.8	1.3	1.0	—
22	9-30	6.80	17	1.5	12	18	12	10	33	14	6.0	10.0	—
JULY.									NIGHT.				
8	5-00	18.0	8.2	5.4	7.8	5.9	2.4	—	3.1	5.2	2.2	2.1	—
19	4-15	17.4	5.2	4.2	2.5	4.5	1.7	3.9	4.7	4.0	2.2	2.1	—
20	4-20	17.1	6.4	2.3	3.1	4.6	1.5	2.8	4.3	3.5	3.6	1.9	—
AUG.													
12	5-10	16.8	—	0.0	2.8	1.8	1.5	2.1	2.7	2.7	4.2	3.9	9.0
13	4-27	17.8	—	3.1	2.8	3.6	1.4	0.21	2.3	0.6	0.0	1.7	—

AUG.		DAY.	RESULTS FOR NO. 6	AND NO. 88
13	9-55	6.50	59	16
14	10-18	6.00	27	36
		NIGHT.		
12	5-10	16.8		4.7

NOTE:—On 21/7/20 and 22/7/20, the sky was overcast and there were some light showers and mist.

For *temperature* records see Table II., page 185.

For *wind* velocity records see Table III., page 186.

TABLE V.—TRANSPIRATION RECORDS.

SERIES A. SUMMER. DAY. IN SUN.

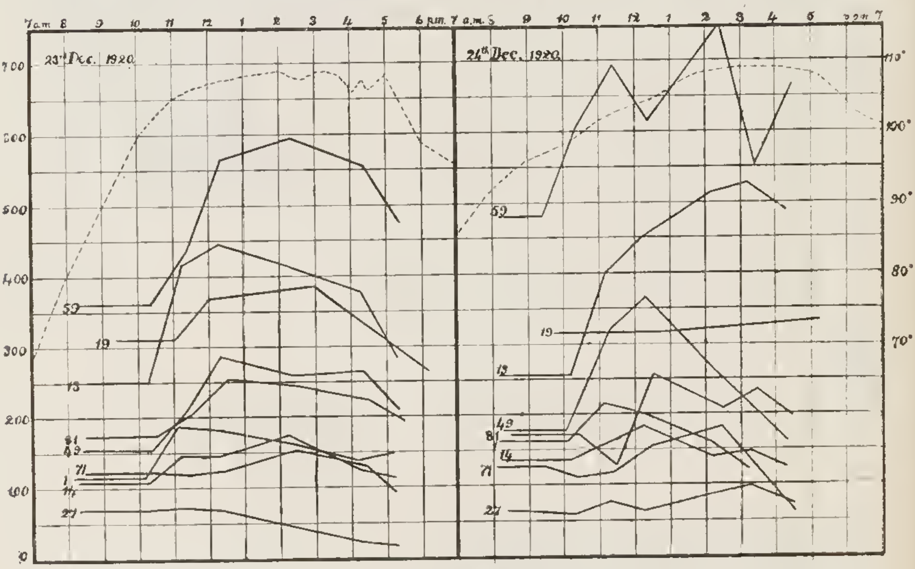
Records of Weighings in grammes per sq. metre per hour.

1920. Dec.	Time From.	No. of Hours.	Register Numbers of Plants.											
			1 3	6	13	14	19	27 28	49	59	71	81	86	88
14	9–30	22.0	14	9	18	10	25	11	16	20	9	21	23	114
15	8–30	8.6	73	61	148	91	195	92	108	212	75	103	215	106
								(27)						
20	11–30	3.0	100	94	242	75	247	20	170	338	91	171	264	164
21	9–00	3.0	112	71	170	112	191	41	133	312	93	133	194	99
,,	12–00	2.0	112	94	197	116	200	40	156	410	120	140	79	26
23	8–8	2.0	118	190	252	109	310	68	152	360	120	174	211	208
	10–8	1.0	188	190	415	147	310	71	209	436	120	204	211	208
	11–8	1.0	182	111	440	147	368	70	285	565	125	252	176	156
	12–12	2.0	163	312	415	172	384	43	260	595	154	244	317	174
	2–10	2.0	139	312	376	125	384	21	264	553	131	223	317	174
	4–8	1.0	149	152	298	113	264	16	205	474	83	192	216	110
24	8–10	2.0	164	219	254	136	315	60	177	544	120	175	52	208
	10–12	1.0	217	219	400	202	315	78	320	693	120	140	52	208
	11–10	1.0	202	219	450	182	315	63	365	616	154	253	52	208
	12–10	2.0	186	219	512	143	315	87	256	750	184	207	52	208
	2–10	2.0	124	164	525	147	332	96	209	553	128	246	211	171
	3–10	1.0	—	164	490	127	332	76	262	664	74	200	211	171
30	9–0	1.0	115		136	84	—	52	95	316	48	131	—	—
	10–0	1.0	102		197	68	—	74	133	316	91	118	—	—
	11–0	1.0	93		242	136	—	88	167	379	117	161	—	—
	12–0	1.0	118		212	170	—	74	175	389	142	157	—	—
	1–0	2.0	121		300	143	—	37	175	424	136	133	—	—
	3–0	1.0	139		340	154	—	23	167	379	128	104	—	—
31	8–30	2 0	—	139	—	—	220	—	—	—	—	—	—	156
	10–30	2.0	—	123	—	—	300	—	—	—	—	—	—	156
	12–30	2.0	—	139	—	—	251	—	—	—	—	—	—	135
1921. Feb. 10	10–40	2.0	178	242	300	140	—	56	190	455	88	—	—	—
	12–45	1.0	178	242	300	114	—	68	203	455	104	—	—	—
	1–45	1.0	207	236	419	117	—	76	214	494	93	—	—	—
	2–45	1.0	148	251	309	93	—	72	146	486	115	—	—	—
11	10–5	2.0	192	266	394	214	—	51	209	675	112	—	—	—
	12–5	1.25	—		436									
	12–5	2.0	172	221	363	191	—	27	200	649	120	—	—	—
	2–5	1.0	148	207	363	186	—	24	171	735	128	—	—	—

1920. Dec.	Time From	No. of Hours	1 3	6	13	14	19	27 28	49	59	71	81	86	88
1920. Dec.									Day.		Shade.			
30	9–0	3.0		49			100							42
	12–0	3 0		49			121							42
	3–0	1.1		2			98							14
31	9–0	2.0	93	—	188	79	—	30	123	212	75	66	—	—
	11–0	2.0	62	—	182	102	—	33	106	275	80	47	—	—
	1–0	2.0	81	—	203	61	—	44	131	218	78	46	—	—
1920. Dec.										Night.				
20	2–40	18.3	14	4.9	21	13	13	4.3	23	27	95	12	33	7.3
1921. Jan.														
4	8–0	1.0	—	—	36	23	16	1.5						
	9–0	1.0	28	41	24	23	5.2	3.2	0	11	11	12	—	13
Feb.														
10	3–45	18.3	38	30	48	26	—	6.5	27	—	19	—	—	—

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

Fig. 1.—Transpiration Curves, Series A, Table V.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

Nos. 27, 28, 29. ACACIA LONGIFOLIA (Sallow Acacia).

Description.—Bentham, Vol. II., p. 397 (4); F. v. M. (34).

Epidermis.—The epidermis of this phyllode as mentioned above is one of the toughest dealt with. It stained well with gentian-violet.

Area.—*Nos. 27 and 28*: The area was found by taking 19 types and comparing all phyllodia with these. *No. 29*: The area was found by making tracings of the phyllodia. Table I., p. 184.

Stomata.—They are arranged very evenly on both surfaces of the phyllode, the general direction of the long axes of the pores being parallel to the longitudinal venules. They are slightly more densely grouped along the main venules. The highest number recorded was 260 per sq. mm., the average being 155 per sq. mm. for both sides of the phyllode. The number tends to increase towards the apex. On No. 29 (the seedling) the average was 158 per sq. mm, the highest individual record being 270 per sq. mm. The size varies very little, the average being 35 x 27 micra.

On No. 29, the average size was 27 x 19 micra. There are two subsidiary cells, with the long axes lying parallel to that of the pore. Sometimes one or both of the subsidiary cells are divided into two by a thin transverse wall at right angles to the long axis of the pore. Plates XIV. and XV., Nos. 27, 27 (a), and 29; Table XI., p. 225.

Glands.—Absent.

Hairs.—On the phyllodia of the older plants a few simple hairs are scattered along the main venules; the number on the young plant is greater.

Transpiration Experiments.—See Tables IV., V., XI., pp. 194, 195, and 225; Figs. 1 and 2, pp. 196 and 198.

Nos. 27, 28. ACACIA LONGIFOLIA.

On 24/12/20, the strong wind which was blowing overturned the plant (No. 27) just after 10 a.m., and unsealed it. It was immediately watered, re-sealed, and again placed in commission. From an examination of the data for 23/12/20 and 24/12/20, it will be seen that the supply of water in the 6in. pot was insufficient for the plant for a day.

To test this plant further experiments were made on 6/1/21 and 7/1/21—two days on which the temperature rose to 90° F., or slightly over, and on each day there was a good breeze, but at different hours. See Table III., p. 186. Nos. 27 and 28 were used. They were well watered and a further supply of water was also put into the vessels in which the pots were standing, so that the bottom of the pot was under water.

On 6/1/21, hourly weighings from 9 a.m. to 12 noon gave transpiration results as follow: No. 27—80, 105, 108; No. 28—99, 88, 108.

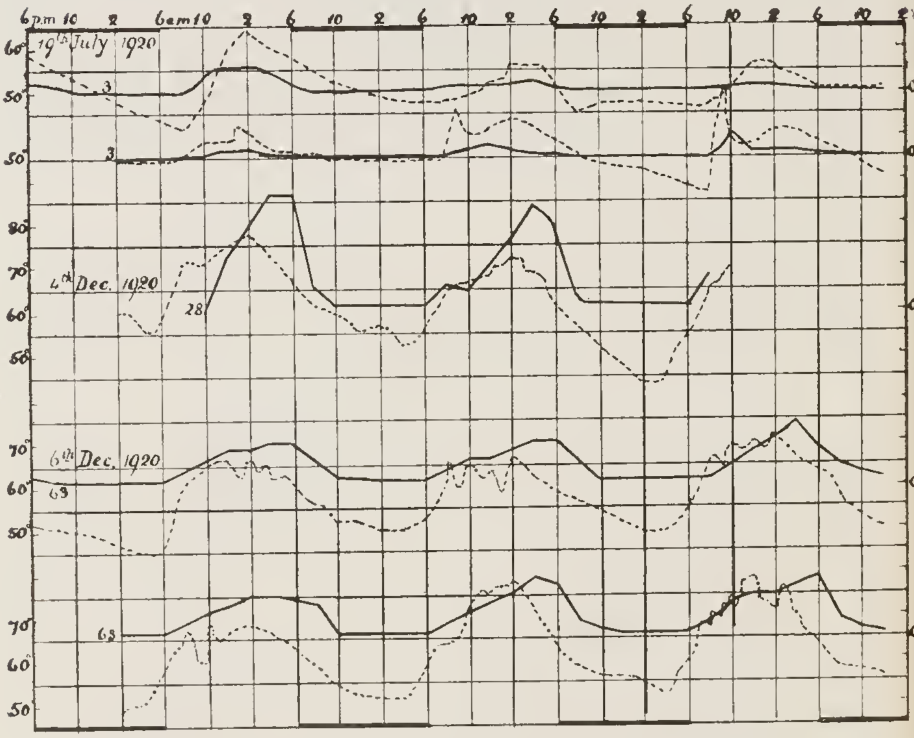
On 7/1/21, hourly weighings from 10 a.m. to 5 p.m. gave the following results with No. 27: 126, 131, 137, 106, 63, 37, 23, giving an average transpiration rate per hour of 90.

On 7/1/21, the weight of water in grms. given off per hour from 10 a.m. to 5 p.m. was as follows: 70, 73, 76.1, 59, 35.5, 20.5, 13, which gives 3.3 grms. per million stomata per hour for the day.

For 23/12/20 it was only 2.6 grms. per million stomata, so that it is evident that the water supply on 23/12/20 was insufficient. This plant has the lowest transpiration rate of any of the plants studied except No. 35. Even on the hottest day, when the water supply was insufficient, the old phyllodia did not wilt or turn yellow, as they did on the younger and smaller plant.

No. 28 was used on the transpiration balance from 10 a.m. on 4/12/20 to 8 a.m. on 6/12/20. The thermometer was not in the tower with the transpiration balance. Fig. 2, p. 198.

Fig. 2.—Records of experiments with Nos. 3, 28, and 63, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F.; those on the right the zero of transpiration. The temperature curve is dotted.

Transpiration experiments (No. 29). Tables VIII, IX., XI. pp. 214, 216, and 225; Fig. 6, p. 215.

In the final experiments on 10/2/21 and 11/2/21, the supply of water was insufficient, and on the 10th, some of the young phyllodia had begun to droop, but recovered before next morning. During the 11th all the large phyllodia began to turn yellow, and the plant did not recover. The average transpiration rate of No. 29 is a little above that of Nos. 27 and 28 for the two days 6/1/21 and 7/1/21, when the water supply was adequate for the larger plants.

No. 31. Acacia podalyrafolia.

Description.—Bentham, Vol. II., p. 374 (4).

Epidermis.—Is tough and easily removed.

Area.—Table I., p. 184.

Stomata.—Are distributed over both surfaces, the highest record being 260 per sq. mm., but the average number for both sides was 200 per sq. mm. They are uniform in size, the average being 29 x 16 micra. There are two subsidiary cells, and their long axes lie parallel to that of the pore. Plate XV., Nos. 31 and 31(a); Table XI., p. 225.

Glands.—Absent.

Hairs.—The whole of both sides of the phyllodia is covered with simple hairs, numbering between 30 and 40 per sq. mm. Plate XV., No. 31 (a).

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205.

No. 33. Acacia saligna.

Description.—Bentham, Vol. II., p. 364 (4).

Epidermis.—Stained well with gentian-violet, but not so deeply as in the other Acacias. It is noticeable, too, that the transverse cell walls are not so thick as in most of the others.

Area.—Table I., p. 184.

Stomata.—Are very regularly arranged, but sometimes the numbers increase towards the apex of the phyllode. The highest record was 350 per sq. mm. near the apex; but the average for both sides was 250 per sq. mm. They are fairly regular in size, and many of them are almost circular in outline, the average size being 23 x 20 micra. The subsidiary cells are two in number, with the long axes parallel to the long axis of the pore. They did not stain so well as the other cells of the epidermis. Plate XV., No. 33; Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 3, p. 201.

It was not used in the winter experiments. The highest summer record was 108 on 7/1/21.

This plant was weighed only on 6/1/21 and 7/1/21, and the following are the records.

		a.m.				p.m.		
	Time from . .	9	10	11	12	1	2	3	4
6/1/21	grms. per sq. . . .	88	80	73	—	—	—	—	—
7/1/21	metre per hr. . . .	—	110	101	102	102	108	99	100

It was placed on the transpiration balance on the evening of 24/12/20. Both the balance and the thermometer were in the tower. After the great heat on 24/12/20, the temperature fell very low on 25/12/20, but the temperature in the tower did not fall so quickly as outside. It will be noticed that, though the temperature curve falls for the greater period of the experiment, the transpiration curve rises and falls at about the usual times. Fig. 3, p. 201.

Nos. 34 and 35. Acacia baileyana (Cootamundra Wattle).

Description.—Maiden, Vol. IV., p. 8 (28).

Epidermis.—The epidermis, which is fairly thick, was removed in the usual way, and stained well with gentian-violet.

Area.—The leaves on each branch were counted and classified into three groups according to the number of pinnules—4, 6, or 8. The average number of leaflets for each of these types respectively was estimated at 84, 130, 197. The average area of a leaflet was taken as .05 sq. cm. Table I., p. 184.

Stomata.—They are very evenly arranged on both sides of the leaflets. The highest record was 280 per sq. mm., the average for both sides being 220 per sq. mm. The size varies very little, the average being 26 x 18 micra. The subsidiary cells are similar to those of No. 33. Plate XV., No. 35; Table XI., p. 225.

Glands.—Absent from the leaflets.

Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 225; Fig. 4, p. 205. It has the lowest transpiration rate of any plant studied

Nos. 40 and 41. Oxylobium ellipticum (Golden Shaggy Pea).

Description.—Bentham, Vol. II., p. 16 (4).

Epidermis.—Is thinner on the under side than on the upper. It stained well with gentian-violet, but unlike those of most stomata, the guard cells did not stain well.

Area.—Table I., p. 184.

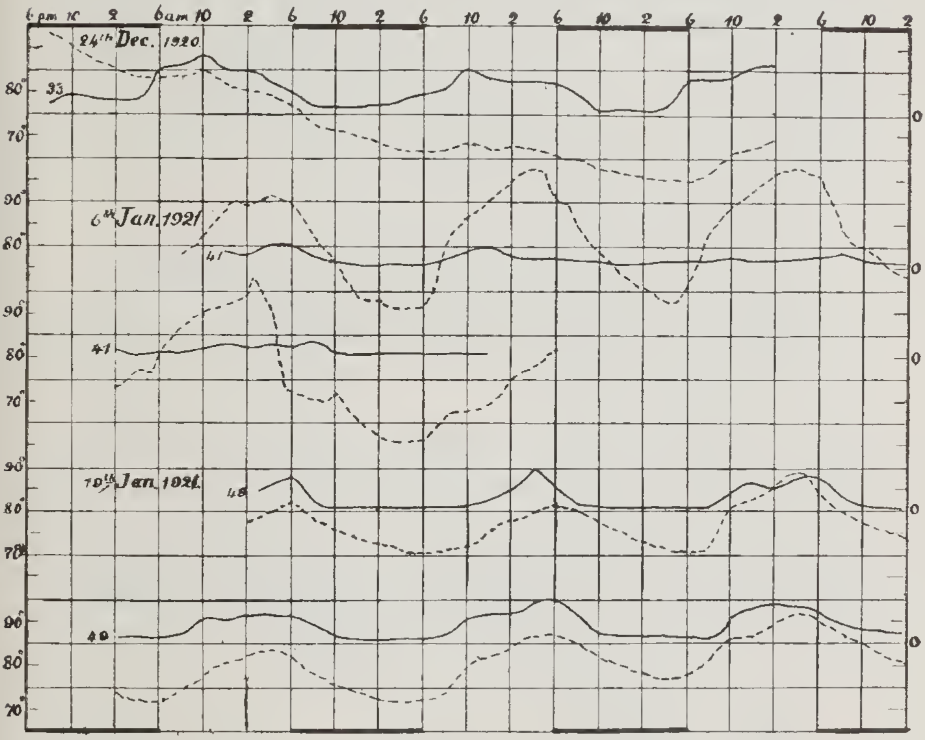
Stomata.—A few are found on the upper epidermis scattered in irregular groups, the number increasing towards the apex. The under epidermis is divided into irregular four-sided areas by lines of elongated, fairly thick-walled cells to which the long simple hairs are attached. The stomata are evenly distributed within these areas as a rule, but sometimes are crowded at the apex. The walls of the guard cells are thin and collapse when treated in the acid solution. They are uniform in size, being 26 x 23 micra. The subsidiary cells are not so definite as in the Acacias. There are usually four, sometimes three, neighbouring cells associated with a stoma, and, of these, there are usually two —one on each side of the pore—with their long axes parallel to that of the pore. Plate XV., No. 40; Table XI., p. 225.

Glands.—Absent.

Hairs.—Both surfaces of very young leaves are densely packed with long, simple hairs; but, in adult leaves, they are absent from the upper surface, and, on the under side, are crowded mainly along the midribs and larger veins.

Transpiration Experiments.—Tables VIII., IX., and XI., pp. 214, 216, and 225; Figs. 3 and 6, pp. 201 and 215.

FIG. 3.—Records of experiments with Nos. 33, 41, and 49, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F., those on the right the zero of transpiration. The temperature curve is dotted.

On 23/12/20, the young leaves began to wilt at 3.30 p.m., but the transpiration curve had begun to decline before that time. Water was added at 4.35 p.m., and the leaves were turgid again in 30 minutes.

On 24/12/20, the upper circles of leaves turned yellow on the upper side and the edges curled under at 2 p.m.; but the very young leaves were not affected. No. 40, which had been out in the open all the time, had its leaves raised almost parallel with the stem, but No. 41 had its leaves only slightly raised. Both plants received very severe shocks on 23/12/20, and were not used again.

The transpiration rate per million stomata for 23/12/20 was 6.2 grms. per hour; but this is a little below the normal, as the water supply was insufficient later in the day.

Nos. 42 and 43. Oxylobium lineare.

Description.—Bentham, Vol. II., p. 17 (4).

Epidermis.—As in No. 40.

Area.—Table I., p. 184.

Stomata.—The number on the upper surface is greater than in No. 40 and they are more generally distributed, being about 60 per sq. mm.; otherwise, the arrangement agrees with that in No. 40.

The highest number recorded was 390 per sq. mm. near the midrib at the base of the leaf, the average number for the underside being 250 per sq. mm. The average for the whole leaf was 155 per sq. mm. The size is uniformly 26 x 18 micra; and the subsidiary cells are similar to those of No. 40. Plate XV., No. 42.

Glands and Hairs.—As in No. 40.

Transpiration Experiments.—See Tables VIII., IX., XI., pp. 214, 216, and 225; Fig. 6, p. 215.

No. 44. Pultenaea daphnoides (Large-leaf Bush Pea).

Description.—Bentham, Vol. II., p. 112 (4).

Epidermis.—The epidermis is fairly thick and stained well with gentian-violet except the guard cells of the stomata.

Area.—Table I., p. 184.

Stomata.—On the upper suface of the leaf, there are a few stomata along each side of the midrib, and a single line, seldom a double line, along the main veins often extending to the edge of the leaf.

On the under side the stomata are arranged fairly evenly over the whole surface; but may be found in clusters near the apex. The highest record was 390 per sq. mm., but the average number was 250 per sq. mm. The usual size is 29 x 21 micra, but those on the upper side are slightly smaller. The subsidiary cells are similar to those of No. 40. Plate XV., No. 44; Table XI., p. 225.

Glands.—Absent.

Hairs.—There are a few arranged evenly over the whole of the under surface, but closely set along the midrib. The bases of two can be seen on Plate XV., No. 44.

Transpiration experiments.—See Tables VIII. and XI., pp. 214 and 225.

The plants did not grow well, so were not used in the summer experiments. The leaves moved into an erect position when the temperature rose above 100° F. on 23/12/20.

No. 47. Pimelea flava (Yellow Rice Flower).

Description.—Bentham, Vol. VI., p. 29 (4).

Epidermis.—The under epidermis is a little thinner than the upper. It stained well with gentian-violet.

Area.—Ten leaves were taken as types and all leaves were classified in size according to these. Table I., p. 184.

Stomata.—There are very few on the upper surface and these usually form a single line — sometimes double on a large leaf, along the midrib. A few may also be found scattered about the apex away from the midrib. On the under surface they are evenly distributed over the whole of it. They are uniform in size, being 42 x 34 micra, and are larger than those of most of the plants studied, except one or two of the Eucalypts, and *Hakea gibbosa.*

The stomata are usually associated with 4 epidermal cells, but they can hardly be called subsidiary cells, for they are not arranged symmetrically with the stomata. (cf. Solereder, Vol. I., 717(40)). Plate XV., No. 47; Table XI., p. 225.

Glands and Hairs.—Absent.

Transpiration experiments.—See Tables VIII., IX., and XI., pp. 214, 216, and 225; Fig. 6, p. 215.

The leaves on this plant become almost erect when the temperature rises above 100° F., and they are exposed to the sun's rays.

No. 49. Eugenia Smithii (Lilly Pilly).

Description.—Bentham, Vol. III., p. 282 (4); F. v. M. (34).

Epidermis.—Was easily removed. On both sides it is thick and tough, but the tissues beneath separate off easily. It stained fairly well with gentian-violet. The vertical walls of the cells of the epidermis are sinuate.

Area.—Table I., p. 184.

Stomata.—There are no stomata on the upper surface, but they are fairly evenly distributed over the whole of the under surface with a tendency to crowd along the midrib and at the apex. The highest record was 300 per sq. mm., the average being 230 per sq. mm. They vary little in size, and on the average measure 31 x 26 micra. The pore is short compared with the length of the guard cells. The stomata are associated with 4 or 6 cells adjacent to them, but these cannot be called subsidiary cells. Plate XV., No. 49; Table XI., p. 225.

Glands.—Are numerous on both sides, averaging from 5 to 7 per sq. mm.

Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 225, Figs. 1 and 3, pp. 196 and 201.

There was no change in the foliage of the plant at the conclusion of the experiments.

The experiment on the transpiration balance continued from the 19th to 24/1/21, both the thermometer and the transpiration balance being in the tower.

Changes were not so abrupt inside the tower. Here again the transpiration curve roughly coincides with the temperature curve, except at night, when the transpiration rate varies very little, it was at its lowest usually between 2 a.m. and 3 a.m. Fig. 3, p. 201.

No. 50. Eugenia myrtifolia.

Description.—Bentham, Vol. III., p. 286 (4).

Epidermis.—Not so easy to remove as that of No. 49, but the cells are similar in shape.

Area.—Table I., p. 184.

Stomata.—There are none on the upper surface. On the under surface they are fairly evenly arranged, but tend to increase in number from base to apex, and also to form clusters near the midrib or near the veins. The number varies on different leaves, the older, larger leaves having less per sq. mm.

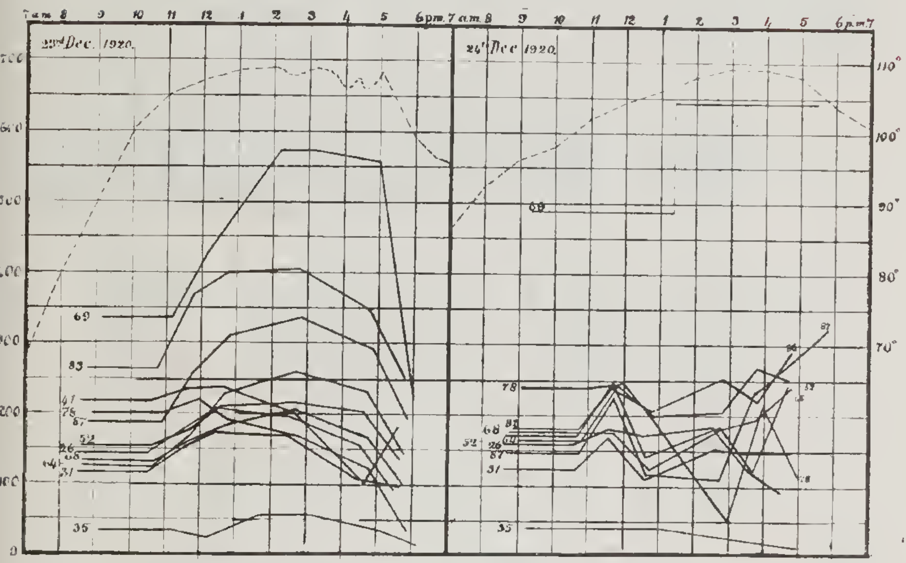
TABLE VI.—TRANSPIRATION RECORDS.

SERIES B. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920 July.	Time From	No. of Hours	Register Numbers of Plants.											
			26	31	34 35	40	50	52	64	58	69	78	83	87
9	11–45	5.0	38	15	32	67	43	54	52	55	76	21		
13	11–15	5.0	24	14	12	31	38	28	25	13	56	2.6		
16	11–15	4.8	26	59	44	27	47	55	82	50	76	7.3		
19	11–20	4.8	34	37	36	103	56	59	98	59	104	—	62	
20	9–45	6.8	31	52	31	91	40	56	80	50	102		56	
AUG.														
13	10–0	6.5	58	62	41	83	—	—	78	42	91	11	72	32
14	10–30	6.0	56	45	42	105			58	60	88	16	78	37
JULY.									DAY.		IN SHADE.			
15	9–15	6.7	7.5	8.1	13	30	27	21	21	12	26	12		
21	9–30	24.0	1.4	1.1	0.8	2	6.3	3.7	4.2	1.6	8.8		6.2	
22	9–40	6.6	0	4.3	12	23	19	17	11	17	26		23	
JULY.											NIGHT.			
8	4–30	18.0	2.3	3.2	3.1	18	10	6.9	6.6	4.1	13	2.1		
13	4–40	17.0	4.4	3.5	3.9	2.6	14	6.4	6.1	10	9.6	4.7		
14	9–40	23.3	1.9	0	2.9	7.0	2.7	3.2	3.8	0.8	12	0.86		
15	3–45	19–5	4.7	3.8	1.8	1.1	2.7	3.2	4.7	0.0	10	1.3		
19	4–15	17.5	1.9	1.6	2.9	5.0	11	8.0	7.5	5.0	1.5	10		
20	4–20	17.5	1.9	0.0	1.0	5.0	16	5.8	5.2	5.8	12	7.1		
AUG.														
12	5–5	16.7	2.3	0.5	0.26	6.0			4.7	4.1	8.8	1.7	6.8	2.3
13	4–30	18.0	0	0	1.3	2.0			3.8	0	7.4	0	5.0	0

FIG. 4.—Transpiration Curves, Series B, Table VII.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right, temperature in degrees F. The temperature curve is dotted.

TABLE VII.—TRANSPIRATION RECORDS.

SERIES B. SUMMER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. DEC.	TIME FROM	NO. OF HOURS.	Register Numbers of Plants. 26	31	34 35	40 41	52	64	68	69	78	83	87
15	9-10	8.5	98	84	20	158	95	134	58	206	117	160	98
20	10-0	4.0	89	102	30	215	147	37	125	294	220	200	157
21	8-30	3.0	98	90	33	101	126	143	120	320	150	221	135
21	11-25	2.0	76	112	30	76	110	171	137	340	157	232	144
23	8-30	2.0	145	117	35	207	154	126	132	334	200	264	188
	10-30	1.0	172	150	26	234	175	168	161	427	221	366	260
	11.30	1.0	206	173	57	238	210	228	183	570	189	396	310
	12-30	2.0	199	172	57	200	216	260	202	570	166	404	337
	2-25	2.0	157	108	36	103	202	243	168	555	121	348	292
	4-25	1.0	94	98	17	183	140	148	103	228	38	252	194

1920 DEC.	TIME FROM	NO. OF HOURS	Register Numbers of Plants.										
			26	31	34 35	40 41	52	64	68	69	78	83	87
24	8-30	2.0	158	123	38	127	171	160	173	485	237	177	147
	10 30	1.0	170	169	38	167	246	238	173	485	242	240	227
	11-30	1.0	160	110	38	156	140	196	122	485	185	202	114
	12-20	2.0	182	153	13	206	185	203	180	640	65	252	106
	2-30	1.0	126	148	13	216	122	266	192	640	210	216	227
	3-30	1.0	92	150	13	175	241	252	240	640	115	288	320
30	9-20	1.0	138	101	37	81	129	140	72		88	156	
	10-20	1.0	131	80	55	69	105	161	125		126	144	
	11-20	1.0	150	117	47	89	117	172	110		89	146	
	12-20	1.0	158	97	78	89	164	185	142		258	106	
	2-20	2.0	92	179	85	106	152	228	139		260	127	
	3-20	1.0	102	118	66	95	140	182	120		185	120	
31	9-25	2.0								336			
	11-25	2.0								348			
	1-25	2.0								388			
1921. FEB. 10	11-0	2.0	154				82	168		129	143		
	1-3	1.0	147				117	224		160	346		
	2-10	1.0	136				140	254		278	382		
	3-10	1.0	90				117	195		180	267		
11	10-30	2.0	88				164	123		201	178		
	12-30	2.0	88				187	125		206	95		
	2-30	1.0	88				164	168		248	95		
1920. DEC.									Day.		Shade.		
30	9-20	6.0								161			
31	9-25	2.0	44	65	46	46	82	123	89	336	101	89	
	11-25	2.0	51	75	46	68	89	137	70	348	109	60	
	1-25	2.0	32	88	50	76	66	157	65	388	105	50	
									Night.				
1920. DEC. 20	2-0	18.4	14	16	4.0	32	19	13	18	52	23	52	17
1921. JAN. 4	8-30	2.0	9	9	5	0	-	7	7	74	7		
FEB. 10	10-30	18.3	13				28	25		36	25	36	

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

The highest record was 860 per sq. mm., the average being 540 per sq. mm. They are uniform in size, being 21 x 18 micra. The stomata are more definitely associated with the cells lying to right and left of them, hence, these may be considered as subsidiary cells. Plate XV., No. 50; Table XI., p. 225.

Glands are not so numerous as in No. 49.

Hairs.—Absent.

Transpiration experiments.—See Tables VI. and XI., pp. 204 and 225. The leaves became diseased, and the plant was not used in the summer experiments.

Nos. 52 and 53. Eucalyptus macrorrhyncha (Red Stringybark).

Description.—F. v. M., Dec. 1 (32); Maiden, Vol. VIII., p. 225 (27).

Epidermis.—The epidermis was not easily removed. It stained well with gentian-violet.

Area.—On 29/7/20, there were 13 leaves, the area of the largest being 11.9 sq. cm. Nine of these had the characters of juvenile leaves. On 29/12/20, there were 23 leaves, the area of the largest being 20.0 sq. cm. Five of these had juvenile characters. Table I., p. 184.

Stomata.—There is a slight tendency to clustering along the midrib and main veins. On the juvenile leaves the numbers on the two sides vary.

The highest records for each side were (a) 150, and (b) 330 per sq. mm.

The average for each side was (a) 110, (b) 270 per sq. mm. Plate XVI., Nos. 52 and 52 (a).

On the older leaves, from which the hairs are absent, the highest records were (a) side 190, (b) side 390 per sq. mm., the average for each side being 160 and 270 per sq. mm. respectively. The average for the whole plant was taken as 210 per sq. mm. The size varies a good deal in growing leaves, but there is not much difference between those on opposite sides of the same type of leaf. Those on the leaves without hairs are slightly larger than those on the younger type of leaf. The average size is (a) side, 31 x 23 micra; (b) side, 34 x 26 micra. Plate XVI., 52 (b).

The stomata are surrounded by 3 or 4, seldom more, irregularly arranged subsidiary cells, which stain slightly deeper than the remainder of the epidermal cells — so stand out more plainly in the preparation.

Glands and Hairs.—They are associated in these leaves; the numerous glands on both sides of the juvenile leaf—10 per sq. mm. —being surrounded by simple hairs with broad bases, the number varying from 5 to 12 per gland. These clusters of hairs give the leaves and stems a rough appearance (cf. F. v. M., Dec. 1 (32)). Plate XVI., No. 52 (a).

The hairs are not stellate, but each simple hair is developed from one of the epidermal cells surrounding the gland (c.f. Maiden, Vol VIII., p. 225 (27)).

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 225; Fig. 4, p. 205.

Nos. 59 and 61. EUCALYPTUS BOTRYOIDES (Gippsland Mahogany).

Description.—F. v. M., Dec. IV. (32); Maiden, Vol. III., p. 50 (27); Bailey (1); F. v. M. (63).

Epidermis.—The epidermis is thick, tough, and easily removed.

Area.—Table I., p. 184.

Stomata.—On the upper surface, there are usually a few stomata along both sides of the midrib. On the under surface they are arranged fairly evenly over the whole surface, but clusters may be found in the middle of the leaf. The highest record for No. 59 was 740 per sq. mm., the average being 610. On No. 62 (one year old seedling) the epidermis was too thin to remove. The leaf was treated with a weak solution of nitric acid, stained, and examined between two large cover-slips. There were very few stomata on the upper side and the highest record on the under side was 330 per sq. mm., the average being 280. They are very uniform in size, being 42 x 31 micra on the larger, older leaves, and 26 x 21 micra on the younger. The subsidiary cells are similar to those of No. 52. Plate XVI., No. 59; Table XI., p. 225.

Glands.—Average about 5 per sq. mm.

Hairs.—Absent.

Transpiration experiments.—See Tables IV., V., XI., pp. 194, 195, and 225; Fig. 1, p. 196. The highest summer records were 592 on 23/12/20, and 750 on 24/12/20. This plant has the highest transpiration rate of any of the plants studied. On 24/12/20, the transpiration rate rose high above that of the day before, so that it was apparently increased by the high wind velocity. The only change noticed in the foliage during the course of the experiments was that the very small leaves at the top were slightly scorched on 10/2/21. Even the heat and wind on 24/12/20 did not scorch the leaves, although some of the Eucalypts growing in the enclosure had their young leaves scorched, and all the leaves of the elm trees along Sydney Road were scorched, turned yellow, and fell in a few days.

Nos. 63, 64, and 66. EUCALYPTUS GLOBULUS (Blue Gum).

Description.—Maiden, XCVII., p. 249 (27); F. v. M. (34).

Epidermis.—Was fairly difficult to remove, as it is comparatively thin and easily breaks up, especially that on the under side.

Area.—Table I., p. 184.

Stomata.—The number of stomata varies a good deal with the shape, size, and age of the leaf. There is a tendency to cluster in the middle parts of the leaf.

On the upper surface there are always a number scattered along each side of the midrib, and usually a few along the main veins. Plate XVI., No. 64 (b)

On the under side, the highest records were 1030, 1020, 970, 960 per sq. mm. on a few leaves.

The following table gives the data from a number of leaves of different sizes taken from the same plant:

No. 64 (Second Year Plant, with juvenile leaves):

Leaf.	Area in sq. cm.	Avge. no. stomata per sq. mm.	Highest no. recorded.
a.	59.3	190	290
b.	48.0	173	260
c.	19.3	315	430
d.	4.0	400	600
e.	4.0	186	200
f.	5.6	190	230

No. 66 (First Year Plant, with juvenile leaves):

a.	19.2	141	190
b.	13.8	178	260
c.	13.0	209	260
d.	12.7	172	210
e.	9.0	152	200

The average number of stomata for No. 64 was 240 per sq. mm. Plate XVI., Nos. 64 and 64 (c). A branch with juvenile leaves was taken from an old tree and the stomata estimated, the average being 220 per sq. mm.

The number on an adult leaf was counted for comparison, and some of the records were as follow:

(a) side	50	50	67	55	per sq. mm.
(b) side	80	146	182	147	per sq. mm.

(cf. F. v. M., Dec VI. (32)). Plate XVI., No. 64 (a).

The size of the stomata varies a good deal. The highest record on juvenile leaves was 39 x 26 micra, the average size being 29 x 23 micra. On the adult leaf the average was 65 x 55 micra. The subsidiary cells are similar to those of No. 52.

Glands.—Are fairly numerous, on the under side only.

Hairs.—Absent.

Transpiration experiments.—See the following tables and figures. For No. 63: Fig. 2, p. 198. No. 64: Tables VI.,VII., and XI., pp. 204, 205, and 225; Figs. 4 and 5, pp. 205 and 213. No. 66: Tables VIII., IX., and XI., pp. 214, 216, and 225.

No. 63 was used only on the transpiration balance in the summer experiments. Fig. 2, p. 198.

No. 64 was also used on the transpiration balance. See Fig. 5, p. 213.

Transpiration experiments.—Interesting points to notice are that there was a fair amount of transpiration during the night, that the lowest point was reached at about 6 a.m., and that the maximum transpiration lagged behind the maximum temperature. No. 63 was used on the transpiration balance on 6/12/20 to 12/12/20. The plant was in the tower and the thermometer in the meteor shed. The curve is very like that of No. 64. It will be noticed that the maximum transpiration was usually between 4 and 6 p.m.—much behind what it was outside in the sun. The maxium temperature was over 20° below that of the 31/12/20, but the transpiration curve followed the temperature curve, and the transpiration at night was much lower. Sudden changes in temperature, unless very great, affected the transpiration curve very little.

No. 66. Not many records were made of No. 66. The daily average transpiration rate on 23/12/20 was 102, and on 24/12/20 was 233, so the wind apparently greatly increased the transpiration rate of the seedling.

Nos. 67 and 68. Eucalyptus alpina (Grampians Gum).

Description.—F. v. M. (31), (32), (34).

Epidermis.—The adult leaves have such a thick epidermis and the tissues beneath are so closely associated with it, that it was not possible to remove the epidermis as a whole, so it was removed in strips. The whole of the tissues of the leaf beneath the epidermis consist of rows of palisade cells, reticulated with large secretory canals. The juvenile leaves are rough-looking, but soft. The venules are prominent on the under side. Care was needed to remove the epidermis whole, as it is fairly thin and closely associated with the venules.

Area.—Table I., p. 184.

On 29/12/20, No. 68 had 40 leaves, the total area being 209 sq. cm. Nine of these leaves were smooth and more like adult leaves, the other 31 appeared warty and rough.

Stomata.—On No. 67 (adult), they are arranged evenly over both surfaces in small clusters. On the upper surface, they are sunk to the lower level of the epidermis, and are not so numerous as on the underside. Plate XVI., Nos. 67 (a), 67 (b), and 67 (c). The highest record for the upper side was 170 per sq. mm, the average being 110. The highest record for the under side was 200, the average being 152 per sq. mm. The average for both sides was 132 per sq. mm.

F. v. M., in Eucalyptographia, Dec. 1, gives 70 and 90 per sq. mm. in the adult, so probably the specimens were taken from an older tree.

On No. 68 (the Seedling), the number varied with the size and the age of the leaf. The highest record for the upper side was 360, the average being 120 per sq. mm. The highest record for the under side was 570, the average being 284 per sq. mm.

Where the record was high, there was no gland with its ring of hairs in the field; but usually a gland or part of a gland took up part of the field when counting the stomata. A few records will show the difference. They are taken from the under side of the leaf:

No gland in the field .	—	430	570	430	510	—	—
One gland in the field .	330	290	230	260	180	150	90

On No. 67 (adult), the size is uniform. On the upper side the average is 70 x 65 micra; on the under side 52 x 47 micra. They vary more in No. 68 (seedling) than in the adult, the average sizes being as follow: Upper, 31 x 26 micra; under, 29 x 18 micra. Plate XVII., No. 68. The subsidiary cells of No. 67 consist of either six or eight, more or less, elongated cells closely associated with each stoma, which stained slightly darker than the other epidermal cells. On No. 68, they are similar to those of No. 52.

Glands.—On No. 67, the average number is about 1 per sq. mm. on both sides, although they are slightly more numerous on the under side. The greater number are about the size of the large stomata, and at first sight might be taken for stomata, but the epidermal cells associated with them have their long axes parallel to the radii of the gland, are narrow, and their thick lateral walls advance to the inner walls of the gland, the opening of which is partly closed by a membrane. The very large openings of the excretory cavities have no protection over the openings.

On the upper side of the leaves of No. 68 there are from 5 to 6 glands per sq. mm., and on the under about 3 or 4 per sq. mm. They are surrounded by a number of simple hairs. Plate XVII., No. 68 (a).

Hairs.—No. 67: Absent.

No. 68: On both surfaces there are numerous simple hairs associated with the glands as in No. 52, but the number per gland is greater than in No. 52, also the hairs on the upper side are shorter and more numerous than those on the under side. Plate XVII., No. 68 (a).

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 225; Fig. 4, p. 205.

No. 69. Eucalyptus cladocalyx (Sugar Gum).

Description.—F. v. M. (31), (32), (34); Maiden, Vol. IV., p. 161 (27).

Epidermis.—Was removed fairly easily and stained well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—On the upper side of the leaf there are always a few stomata along each side of the midrib to about the middle of the leaf; and one or two may be found along the main veins. On the under side they are arranged evenly all over the surface. The highest record was 410 per sq. mm. The average for the smaller, younger leaves is 320; for the larger, older leaves 220 per sq. mm. They are uniform in size, being 31 x 23 micra. The subsidiary cells are similar to those of No. 52. Plate XVII., No. 69.

Glands.—Average about 1 per sq. mm. on the under side.

Hairs.—Absent.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 226; Fig. 4, p. 205.

The highest summer records were 570 on 23/12/20 and 640 on 24/12/20. Its transpiration rate is second only to No. 59. The wind on 24/12/20 greatly increased the transpiration. Temperatures over 100° F. seemed to cause excessive transpiration in this plant. Its curve always followed closely on the temperature curve. On 10/2/21, the upper leaves wilted a little and the transpiration rate dropped quickly. On 23/12/20, and on other very bright, hot days, the edges of the leaves curled upwards.

No. 71. Eucalyptus maculata, var. citriodora (Sweet-scented Gum).

Description.—Bailey (1) and (2); Maiden, Vol. I., p. 154 (28); F. v. M. (31).

The first juvenile leaves averaged about 5 inches when measured on 26/7/20, but on 29/12/20, when the next measurement was made, none of the first leaves was present, and the new ones averaged about 3½ inches in length.

Epidermis.—The epidermis of the juvenile leaves was very difficult to remove whole, as it is very thin on both sides of the leaf. It did not stain very well with gentian-violet, but the glandular hairs did.

Area.—Table I., p. 184.

Stomata (Juvenile leaves).—They are found on both sides of the leaf, the greater number being on the under side. They are often densely packed at the apex and also increase in number from the margins to the midrib. They have a tendency to form clusters about the glandular hairs. On the upper side, the highest records were 550, 410, and 280 per sq. mm., but the average number was 160. On the under side, the highest records were 710, 650, and 640 per sq. mm., but the average number was 460, hence, the average for the two sides was 310 per sq. mm. Plate XVII., Nos. 71 and 71 (b).

The *Adult leaves* were obtained from a large tree. Stomata are found on both sides. The average for (a) side was 366, for (b) side 330 per sq. mm. F. v. M. (32) gives the numbers as follow: (a) side, 153 and 180; (b) side, 205 and 225 per sq. mm. Plate XVII., No. 71 (c).

They are fairly uniform in size, although there is usually a small percentage of larger ones on the under side.

Juvenile—	
Upper epidermis	21 x 16 micra
Under epidermis	18 x 16 micra
,, large size	26 x 21 micra
Adult—	
Both sides	21 x 16 micra

The subsidiary cells are similar to those of No. 52.

Glands.—On adult leaves there are few. On juvenile leaves, the glands are numerous on both sides, and have a peculiar structure.

"Is specially noteworthy owing to the fact that in the long narrow leaves and in the branches the secretory cavities are enclosed in hair-like emergencies of cylindrical shape, rounded at the ends, and of epidermal origin." Solereder, Vol. I., p. 353 (40).

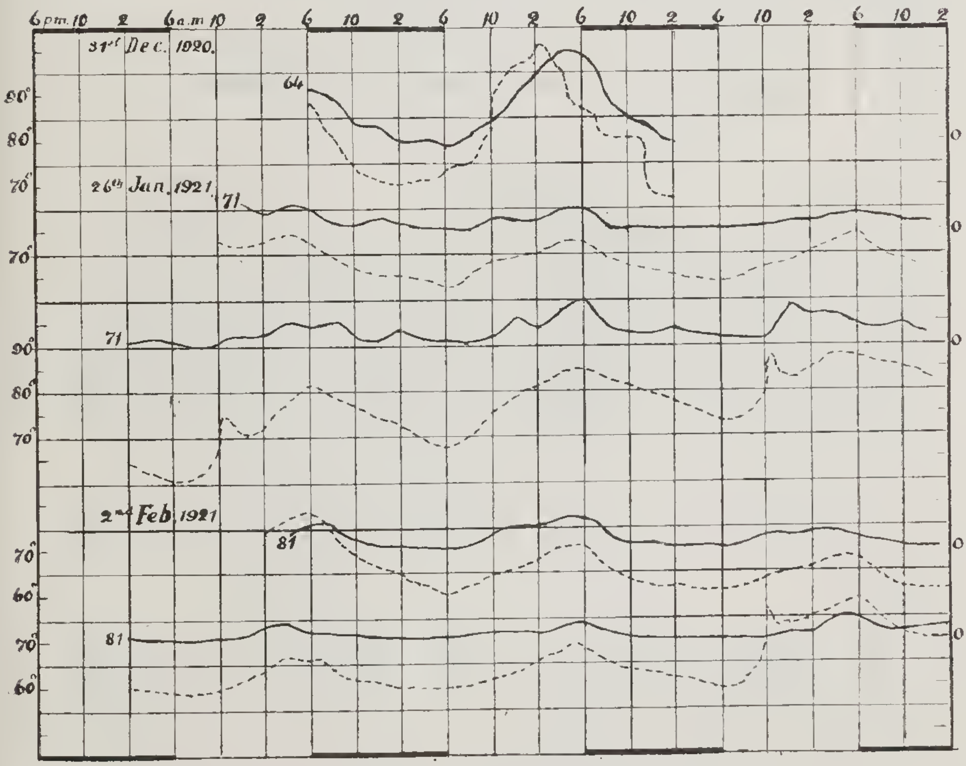
On the upper epidermis, these glandular hairs are shorter than on the under side. They are arranged more or less in groups, and especially along the smaller venules. On the upper side, they average 5, and on the under side, 10 per sq. mm.

Hairs.—Are associated with the glands.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Figs. 1 and 5, pp. 196 and 213. Only when the temperature rose some distance above 100° F. did the transpiration rate rise above 150.

This plant was used on the transpiration balance from 26/1/21 to 31/1/21. Both plant and thermometer were in the tower. Fig. 5, p. 213. The maximum temperature rose higher each day, but the sudden rises on 29/1/21 and 31/1/21 at 10 a.m. were due to raising the blind on the east window of the tower. There was no change in the leaves on completion of the experiments, and the plant grew well afterwards.

Fig. 5.—Records of Experiments with Nos. 64, 71, and 81, on the Transpiration Balance.



The numbers opposite the abscissas on the left denote the temperature in degrees F.; those on the right the zero of transpiration. The temperature curve is dotted.

No. 75. LEPTOSPERMUM LANIGERUM (Woolly Ti-tree).

Description.—Bentham, Vol. III., p. 106 (4).

Epidermis.—This was removed fairly easily, but did not stain well with gentian-violet.

Area.—Was found in the same way as those of Nos. 27 and 47. Table I., p. 184.

Stomata.—Are evenly arranged on both sides. The highest records for both sides were 350, 330, 300, and 260 per sq. mm., and the average for both sides was 240 per sq. mm. The size was uniform on both sides, the average being 23 x 21 micra. The subsidiary cells are similar to those of No. 52. In many cases the cells on each side have their long axes parallel to the pore, and look more like subsidiary cells. Plate XVII., No. 75.

Glands.—Are arranged evenly on both surfaces; but the average for the upper surface is 20, while that of the under surface is 12 to 15 per sq. mm.; but the latter are slightly larger.

Hairs.—Long, thin unicellular hairs are arranged sparsely over most of the upper surface, but densely along the midrib and edges. There are none on the under side.

Transpiration experiments.—See Tables VIII., IX., XI., pp. 214, 216, and 226; Fig. 6, p. 215.

On 10/2/21, when the water supply was meagre, the transpiration rate soon fell, and the leaves wilted although the soil was damp, but they soon recovered when watered.

TABLE VIII.—TRANSPIRATION RECORDS.

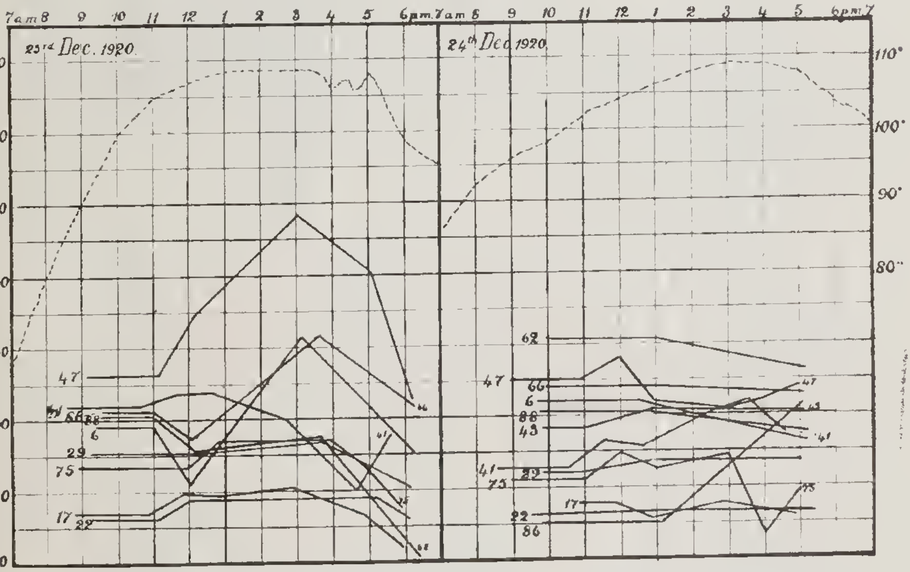
SERIES C. WINTER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. JULY.	TIME FROM	NO. OF HOURS	Register Numbers of Plants. 17	22	29	42	44	47	53	62	66	75
16	10-40	5.2	30	35	50	42	98	89	74	57	25	22
19	2-0	2.5	18	88	56		33	74	41		13	21
20	10-0	6.7	30	29	50	50	113	110	64		76	33
AUG.												
13	10-30	6.5	30	44	69	62	115	111	58		25	26
14	11-10	5.8	22	59	23	82	105	100	48		13	26
JULY.						DAY.	SHADE.					
12	12-0	3.8	23		11	30	26	78	17			26
13	9-30	6.3	11	9	13	12	20	44	19	16	25	15
15	9-50	4.7	12	6	14	12	16	37	12	23	9	33
22	10-45	6.0	15	7		6	16	37	17			10

1920. JULY.	TIME FROM	NO. OF HOURS.	REGISTER NUMBERS OF PLANTS.									
			17	22	29	42	44	47	53	62	66	75
JULY.								NIGHT.				
12	4-0	17.6	3.0		0.0	3.7	3.3	11.0	4.6			4.7
13	4-0	17.3	2.7	2.9	8.3	6.2	0	3.7	5.2	11	6.3	7.3
14	9-20	24.5	2.7	0	0	2.5	3.3	11	2.9	5.9	3.8	1.5
15	4-30	18.3	0.6	0	1.4	0	3.3	7.4	3.5	0	2.5	2.1
19	4-40	17.5	3.0	2.9	6.9	7.5	4.9	11	5.8		5.1	5.7
20	5-40	17.0	1.7	2.9	1.4	2.5	1.6	15	4.0		1.5	3.1
21	9-50	24.0	3.6	0	1.4	2.5	4.9	7.4	0.6		3.8	3.2
AUG.												
12	5-50	16.8	1.5		1.4	1.2	1.5	26	4.6			2.6
13	5-0	18.3	1.5	0	0	0	0	0	1.2		0	1.0

FIG. 6.—Transpiration Curves, Series C., Table IX.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

TABLE IX.—TRANSPIRATION RECORDS.

SERIES C. SUMMER. DAY. IN SUN.

Records of Weighings in grammes per sq. metre per hour.

1920. Dec.	Time from.	No. of Hours	Register Numbers of Plants.							
			17	22	29	42	47	62	66	75
15	10–20	8.0	50	65	74	69	118	148	142	92
20	10–30	3.0	50	94	124	81	331	200	74	170
21	8–5	3.0	55	63	85	78	169	218	160	107
,,	11–10	2.0	53	77	88	119	250	270	137	126
23	8–50	2.0	70	63	153	186	264	226	102	135
,,	10–50	1.0	99	90	153	186	346	226	102	135
,,	11–50	1.0	95	90	153	186	390	226	102	170
,,	12–50	2.0	105	90	167	186	185	226	102	170
,,	2–50	2.0	68	90	167	186	405	226	102	135
,,	4–50	1.0	21	63	104	186	228	226	102	85
24	8–50	2.0		58	121	183	250			113
,,	10–50	1.0	86	58	121	183	280	304	240	148
,,	11–50	1.0	57	58	121	183	213	304	240	126
,,	12–50	2.0	76	63	135	219	206	261	228	142
,,	2–50	1.0	69	63	135	219	220	261	228	35
,,	3–50	1.0	57	63	135	214	242	261	228	92
30	9–30	1.0	42				88			38
,,	10–30	1.0	63				132			47
,,	11–30	1.0	54				169			63
,,	12–30	1.0	62				198			31
,,	1–30	2.0	64				92			57
,,	3–0	1.0	53				22			31
31	9–30	2.0		18	77	143			114	
,,	11–30	2.0		22	77	147			114	
,,	1–30	2.0		18	67	159			154	
FEB. 1921.										
10	11–20	2.0	71	47	66					72
,,	1–20	1.0	59	36	64					58
,,	2–20	1.0	55	49	76					80
,,	3–20	1.0	42	36	85					69
11	10–40	2.0–	27	18	89					13
,,	12–40	2.0–	27	45	74					16
,,	2–40	1.0	16	36						31
DEC. 1920.							DAY.	SHADE.		
30	9–30	2.0		13	40	36				
,,	11–30	3.5		13	54	60				
,,	3–0	1.0		9	59	71				
31	9–30	2.0	34				88			25
,,	11–30	2.0	41				96			38
,,	2–30	2.0	31				81			10
DEC. 1920.						NIGHT.				
20	1–30	18.5	10	14	18	17	59			25
JAN. 1921.										
4	8–40	2.0	2	4	0	6	0		85	19
FEB.									22	35
10	3–45	18.3		9						

For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

No. 78. Grevillea robusta (Silky Oak).

Description.—Bentham, Vol. V., p. 459 (4).

Epidermis.—It was difficult to remove, as that on the under side was so thin. It did not stain very well with gentian-violet.

Area.—Each leaf was traced on paper and the area found in the usual way. Table I., p. 184.

Stomata.—On the under side only. The venules are so fine that they do not interfere with the arrangement of the stomata. The highest records were 240, 230, 220, and 200 per sq. mm., the average being 180 per sq. mm. The pores are small compared with the size of the guard cells. The stomata vary little in size, the average being 36 x 31 micra. The subsidiary cells are similar to those of No. 52. Plate XVII., No. 78; Table XI., p. 226.

Glands.—There are a few scattered over the upper surface.

Hairs.—Are very fine and thread-like. They are more numerous along the veins on the upper side, but are distributed fairly evenly over the whole of the under surface.

Transpiration experiments.—See Tables VI., VII., and XI., pp. 204, 205, and 226; Fig. 4, p. 205.

Apparently, No. 78 was too large for the pot it was in, and the water supply was inadequate for a day of high temperatures. On 24/12/20, some of the young leaves shrivelled and the larger ones wilted. With an adequate water supply, the transpiration curve followed the rise in temperature, as shown by the records for 30/12/20 and 10/2/21, and its transpiration rate was very high.

No. 81. Hakea gibbosa (Rock Hakea).

Description.—Bentham, Vol. V., p. 513 (4).

The leaves feel leathery and this is due partly to the fact that the epidermis is very thick. It consists of one layer of deep thick-walled cells, the cuticle being much thicker than the inner wall. The leaf is centric in structure, and beneath the epidermis, two layers of palisade cells surround the medullary tissue, which consists mainly of thick-walled cells.

Epidermis.—This was removed similarly to that of Nos. 13 and 17. It stained well with gentian-violet.

Area.—The complete epidermis of a leaf was mounted in glycerine and measured, the average circumference being 3.6 mm. The leaves of each branch were counted and measured against ten types of known lengths, varying from 1.0 cm. to 6.5 cm. On 10/8/20, there were 399 leaves; and of these 63 were 4.1 cm.; 103 were 3.9 cm.; 55 were 3.6 cm.; and 65 were 2.7 cm. in length. On 7/1/21, there were 874 leaves with an area of 1051 sq. cm.

Stomata.—The stomata, as a rule, are arranged evenly over the whole surface, with the long axes of the pores parallel to each other and also to the long axis of the leaf; but, occasionally, clusters are found at the apex. As mentioned above, the epidermal cells have great depth. The guard cells, with the subsidiary cells, have not one-fourth of their depth, hence, the stomata appear depressed almost to the level of the inner surface of the epidermis; and the walls of the epidermal cells surrounding the stomata form a funnel-shaped respiratory cavity above the stomata. Plate XVIII., No. 81 (b). The narrow end of this chamber projects slightly above the outer surface of the epidermis. The highest record was 100 stomata per sq. mm., but the average was 70 per sq. mm. They are uniform in size, being 52 x 36 micra. There is a pair of small subsidiary cells with their long axes parallel to that of the pore. Plate XVII., Nos. 81 and 81 (a); Table XI., p. 226.

Hairs.—Are absent from the adult leaves, but the juvenile leaves are closely set with fine, slender hairs, which give them a silky appearance.

Glands.—Absent.

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Figs. 1 and 5, pp. 196 and 213.

The highest summer records were 252 on 23/12/20 and 253 on 24/12/20. The second day's results were erratic, but the transpiration curve rose to practically the same maximum on both days. The thrashing by the wind might have affected it at first, but it made much the same curve on both days. Apparently a breeze suits it, as it made a similar curve on 30/12/20. It was used on the transpiration balance from 2/2/21 to 7/2/21, both the plant and the thermometer, being in the tower. Fig. 5, p. 213.

At the higher temperatures the transpiration curve almost coincides with the temperature curve, but transpiration was not vigorous day nor night.

The number of stomata is low—70 per sq. mm.—but they are large, though well protected from the wind, and the transpiration rate was low when there was very little wind.

No. 82. Banksia serrata (Saw Banksia).

Description.—Bentham, Vol. V., p. 555 (4); Maiden, Vol. IV., p. 17 (28).

Epidermis.—This is formed of a layer of thick-walled, narrow, but deep cells, the cuticle of which is very much thickened. The epidermis, on the under side, is only .3 to .5 as deep as that on the upper side, but the walls of the cells are very thick.

Hypoderm is developed on both sides of the leaf and consists of one layer of cells about the same size as the corresponding epidermal cells. There is a great amount of sclerenchymatous tissue in the leaf, for all vascular bundles or veins are accompanied by this tissue, and even with the smaller parallel veins it forms vertical transcurrent plates reaching as far as the epidermis on either side and apparently dividing the leaf into compartments of which these plates form the walls. On the upper side of the leaf there is one, sometimes two, layers of palisade cells; and, sometimes, small patches of palisade cells may be found on the under side of the leaf.

Further, the stomata are not distributed evenly over the surface of the epidermis, as is the general rule, but are congregated into pits. They are closely packed on the sides and the floors of these pits, the walls of which are also lined with fine hairs (cf. Hamilton (21)).

Area.—The area of the leaves was found in the usual way. Table I., p. 184.

Pits.—There are no stomata on the upper surface. The under surface of the leaf is covered with pits which average about 14 per sq. mm. These pits are wide open, but the mouth is usually a little narrower than the base (Ampulliforn, according to Mohl. Solereder, p. 711 (40)). The pits vary a good deal in form, and some are single depressions, while others have a single large opening, but soon divide into 2 or 4 smaller pits. The depth of the pits is from .3 to .5 of the thickness of the leaves. The hairs line the ridges and inner walls of the compound pits as well as the outer walls. Plate XVIII., Nos. 82, 82 (c).

Stomata.—To estimate the number of stomata in the pits, series of both horizontal and vertical sections of the leaf were cut, mounted, and examined. Results of the examination of the pits in a series of 11 horizontal sections:

	Pits.				Hairs.	Stomata.		
Pit	Size in mm.					Sides	Base	Total
	L	B	D					
* 1.	.368	× .144	× .100	-	57	28	19	47
* 2.	.240	× .116	× .080	-	44	22	13	35
* 3.	.304	× .60	× .110	-	69	38	28	66
4.	.224	× .128	× .114	-	52	13	16	29
5.	.224	× .112	× .110	-	32	14	12	26
6.	.160	× .096	× .060	-	20	11	18	29
† 7.	.224	× .096	× .070	-	23	15	8	23
8a { 8.	.208	× .096	× .100	-	42	10	13	23
8a { 9.	.176	× .096	× .100	-	39	10	10	20
8a { 10.	.176	× .112	× .100	-	32	11	12	23
8a { 11.	.144	× .128	× .100	-	28	14	6	20
Total for 15 pits	-	-	-	-	438	186	155	341
Average per pit	-	-	-	-	30	12	10	23

* Signifies divided into two pits 4 micra from the surface.

† Signifies divided into two shallow pits. This occurs when the wall of sclerenchyma accompanying a strand passes above the pit.

8 (a) was a pit with a single opening which divided into 4 pits 2 micra from the surface.

The study of these sections showed that there were few stomata around the upper edge of the pits, that there were two, sometimes three, rows of stomata round the walls of the pits; and that they were practically touching end to end, that the bottoms of the pits were almost covered with stomata which were arranged in such a way that the guard cells could not interfere with each other.

Results of the examination of a series of vertical sections through the leaf:

No.	V.S. of Pits. L	B	D	Stomata. End	Side	Base	Total	Hairs. Side	Base	Total
	mm.	mm.	mm.							
1.	.256 ×	.100 ×	.080	18	4	11	33	11	14	25
2.	.192 ×	.100 ×	.080	7	8	7	22	12	8	20
3.	.090 ×	.062 ×	.062	9	4	4	17	8	3	11
4.	.120 ×	.112 ×	.080	7	10	5	22	13	5	18
5.	.170 ×	.144 ×	.096	13	6	12	31	16	10	26
6 × 2.	.210 ×	.192 ×	.096	6	11	20	37	23	16	39
	Total for the seven pits						162			139
	Average per pit - - - -						23			20

A study of these results showed that the hairs were fairly evenly distributed in depth, that there was often a raised portion in the middle of the pit with a number of hairs on it, and that there were usually from 2 to 5 hairs growing on the base of the pit.

TABLE X.—TRANSPIRATION RECORDS.

Series D. SUMMER. Day. In Sun.

Records of Weighings in grammes per sq. metre per hour.

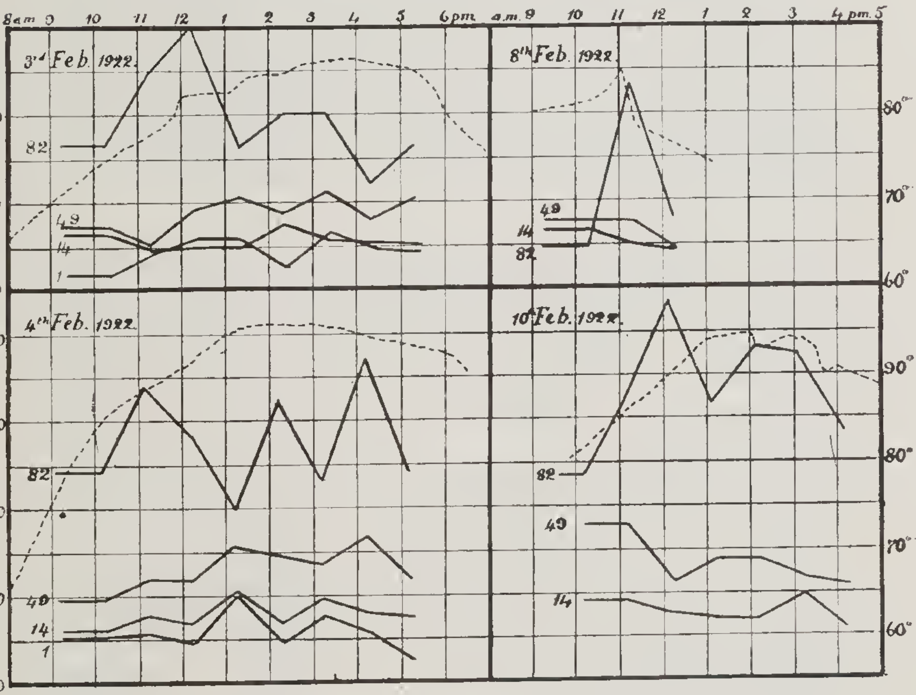
1922. Feb.	Time From.	No. of Hours.	Register Numbers of Plants. 1	14	49	82	X
3	9–15	1	17	64	72	162	
	10–15	1	43	46	53	243	422
	11–15	1	60	50	91	300	790
	12–15	1	56	49	104	162	790
	1–15	1	29	73	88	200	1006
	2–15	1	65	56	112	200	1034
	3–15	1	46	53	80	120	1025
	4–15	1	43	53	101	162	1006
4	9–9	1	51	58	99	243	516
	10–9	1	56	79	120	340	1175
	11–9	1	46	68	117	284	1160
	12–9	1	102	106	115	200	1270
	1–9	1	39	68	144	324	1310
	2–9	1	76	99	136	234	1840
	3–9	1	54	81	168	372	1500
	4–9	1	26	76	120	243	1220

TABLE X. (*Continued*).

1922. Feb.	Time From.	No. of Hours	Register Numbers of Plants.				
			1	11	49	82	X
8	9–15	1	-	68	80	49	291
	10–15	1	-	53	80	235	516
	11–15	1	-	45	48	81	330
10	11–7	1	-	91	176	316	583
	12–7	1	-	79	112	430	1050
	1–7	1	-	71	136	316	1240
	2–7	1	-	70	136	380	1370
	3–7	1	-	99	115	372	1320
	4–7	1	-	61	109	284	940

X = Evaporation from free surface of water.

FIG. 7.—Transpiration Curves, Series D, Table X.



The numbers opposite the abscissas on the left denote grammes per sq. metre per hour; on the right temperature in degrees F. The temperature curve is dotted.

The average number of stomata coincided by the two methods, but the number of hairs differed a great deal. This was probably due to the fact that in the examples taken by the first method there were 5 compound pits, and the number of hairs was then higher as they develop on the ridges separating the pits.

The highest record for a single pit was 33 stomata, the average number being 23 per pit. The average number of hairs may be taken as 25 per pit.

When the under surface is viewed from the outside, the pits seem to be a fair distance apart, but on examining the horizontal sections it is seen that the whole of the under surface is taken up with the system of pits, the boundaries between them being formed by vessels and fibres. Plate XVIII., No. 82. Each pit is surrounded by very open spongy mesophyll, bounded by and separated from, other pits by these vessels and fibres. The average number of pits per sq. mm. is 14. As mentioned above, the stomata are packed closely together in the pits, the average per pit being 23. Hence, the number of stomata per sq. mm. will be 322.

The guard cells stain well with gentian-violet, and look very dark, but they always show as two disconnected masses. The reason for this is understood when a transverse vertical section of the stoma is studied, for it will be seen that the guard cells have comparatively great depth, that they project into the pit, and that the upper or outer half of the guard cell is not stained, because it is cuticularised; so that even in the walls of the pits the armour of the leaf is continued. Plate XVIII., Nos. 82 (a), 82 (b), 82 (d). The size of the stomata is uniform, being 31 x 26 micra. The subsidiary cells are small and the long axes lie parallel to that of the pore.

Glands.—Absent.

Hairs.—Are unicellular, the basal part is thick-walled and cylindrical, terminating in a fine, hair-like thread. They average between 20 and 30 in a pit, and, as they project from the pits, they give the under surface of the leaf its characteristic hoary appearance. They prevent dust and moisture from entering the pits.

Transpiration experiments.—See Tables X. and XI., pp. 220 and 226; Fig. 7, p. 221.

There were no winter records. The highest summer records were 300 on 3/2/22, 372 on 4/2/22, and 430 on 10/2/22. Nos. 49, 14, and 1 were weighed with No. 82 for purposes of comparison. Although there were no great changes in temperature on the above dates, the transpiration curve of No. 82 showed great variation, but those of Nos. 49, 14, and 1 showed almost similar variations, but in much less degree.

The transpiration rate is a fairly high one, and responds readily to increase of temperature.

No. 83. Coprosma Baueri.

Description.—Kirk (23).

Epidermis.—This was easily removed, as the cuticle, especially of the upper surface, is very thick and tough. It did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—They are distributed evenly over the whole under surface. There are none on the upper surface. On a very young leaf the average per sq. mm. was 740. On full grown leaves, the highest record was 660, the average being 400 per sq. mm. The most common size is 23 x 13 micra, but there are usually 10 to 20% of larger ones, measuring 31 x 21 micra. There is a pair of subsidiary cells with the long axes lying parallel to that of the pore. Plate XVIII., No. 83; Table XI., p. 226.

Glands and Hairs.—Absent.

Transpiration experiments. — See Tables IV., V., XI., pp. 204, 205, and 226; Fig. 4, p. 205.

On 24/12/20, all the leaves were wilting about 3 p.m., and their margins were curling under. After 24/12/20, many of the leaves became yellow and fell off.

No. 86. Prostanthera lasiantha (Christmas Bush).

Description.—Bentham, Vol. V., p. 93 (4).

Epidermis.—It required great care to remove the epidermis entire, as it is thin. It stained fairly well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—Are found on the under side only, and are evenly distributed over the whole surface. The highest record was 370, the average being 260 per sq. mm. The guard cells are large, but the pore is relatively small. The average size of the stomata is 29 x 21 micra. There are usually two subsidiary cells lying to the right and left of the stoma with their long axes at right angles to that of the pore.

Glands and Hairs.—The whole of both surfaces of the leaf are covered with evenly arranged glandular hairs, averaging from 15 to 20 per sq. mm. They are spherical in form, and the head is divided, by vertical walls, into 16 sections (cf. Solereder, p. 636 (40)). Plate XVIII., Nos. 86 and 86 (a).

Transpiration experiments.—See Tables IV., V., and XI., pp. 194, 195, and 226; Fig. 6, p. 215.

Few weighings were made with No. 86, and, after 24/12/20, it was useless for experiments, as the leaves turned yellow and died.

No. 87. Veronica Dieffenbachii.

Description.—Cheesman, p. 500 (10).

Epidermis.—It was easily removed, as it is thick and tough, the upper being much thicker than the under. It did not stain very well with gentian-violet.

Area.—The areas of 39 leaves were measured and the total taken as a standard. Table I., p. 184.

Stomata.—There are none on the upper surface, but they are distributed evenly over the whole of the under surface, except where a broad band of thick-walled cells marks the position of the midrib. The highest record was 800, the average being 600 per sq. mm. They are fairly even in size, the average being 31 x 23 micra. There are no definite subsidiary cells. Sometimes 2, 3, or 4 cells are associated with a stoma. Plate XVII., No. 87; Table XI., p. 226.

Glands and Hairs.—The whole of the under surface on which stomata are developed, is also dotted fairly regularly with glandular hairs, averaging between 20 and 30 per sq. mm. They look like small toy balloons. The stalk is comparatively short and stout. The head is almost circular in outline, its diameter being a little shorter than the length of the stalk; and it is divided into two sections by a vertical wall. Plate XVIII., No. 87.

Transpiration experiments.—See Tables VI., VII., XI., pp. 204, 205, and 226; Fig. 4, p. 205.

On 24/12/20, the wind scorched the leaves and they began to turn yellow and curl. Water was added at 2.45 p.m., and, soon after, the transpiration rate rose suddenly.

No. 88. Myoporum insulare (Boobialla).

Description.—F. v. M (34).

Epidermis.—The epidermis was easily removed and cleared from the underlying tissues, as it is very strong and much thickened on both sides of the leaf. The structure of the leaf is uniform, consisting of seven or eight rows of cells more or less rectangular to square in outline, and varying little in size or shape. The veins run through the middle of the lamina and so do not approach the epidermis; hence, the stomata are developed over the whole of the surface, except on the midrib. There are few secretory cavities. The epidermis did not stain well with gentian-violet.

Area.—Table I., p. 184.

Stomata.—They are evenly distributed on both sides of the leaf. The highest record was 110, the average being 80 per sq. mm. for both sides of the leaf.

In vertical transverse section, the guard cells have the appearance of a pair of birds facing each other. The upper and outer parts of the guard cells are cuticularised, and project a little above the surface of the epidermis. The shape of the guard cells causes the formation of a vestibule before the inner respiratory chamber is reached. The stomata are uniform in size, the average being 44 x 31 micra. The subsidiary cells consist of three irregularly shaped cells, grouped round the stoma. Plate XVIII., No. 88; Table XI., p. 226.

Glands and Hairs.—Glandular hairs are numerous on both surfaces of the leaf, being more numerous along the midrib, where they may number from 5 to 10 per sq. mm., but the average number for the rest of the leaf is 2 to 3 per sq. mm. They have short hollow stalks, and the disc-like head is divided by vertical walls into 8 or 10 compartments. The bases of the hairs are depressed slightly below the epidermis, and their heads are level with, or project slightly above, the surface of the epidermis. Plate XVIII., No. 88 (a).

Transpiration experiments.—See Tables IV., V., XI., pp. 194, 195, and 226; Fig. 6, p. 215.

TABLE XI.—RECORDS OF AVERAGE TRANSPIRATION RATES AND STOMATA.

Pl.—Register numbers of plants.

W.—Average Winter Transpiration Rates, 1920.

23(s), 24(s), 30(s), 30(d), 31(s), 31(d)—Average transpiration rates for these dates in December, 1920. (s) = in sun. (d) = in shade.

N.—Average transpiration rates between 8 p.m. and 10 p.m. on 4/1/21. Temperature at 9 p.m., 67° F. Wet bulb, 61.20° F. at 10 p.m 63° F. Wet bulb 58° F.

A.—Average number of stomata per sq. mm. of transpiring surface.

B.—Length of stomata in micra.

C.—Breadth of stomata in micra.

D.—Average transpiration in grammes per million stomata per hour for 8 hours on 23/12/20.

Pl.	W.	23(s)	24(s)	30(s)	30(d)	31(s)	31(d)	N	A	B	C	D	Pl
												GRMS.	
1	33	151	177	115			77	14	320	24	19	4.1	1
6	43	213	201		42	134		20	310	21	18	5.4	6
6										30	26		6
13	43	368	424	246			191	30	500	31	18	5.9	13
14	28	135	152	128			81	23	120	31	25	9.0	14
17	26	85	70	57			36	1	192	23	18	3.5	17
19	34	328	324		107	257		10	183	36	16	14.3	19
22	51	83	60		12	19		2	100	31	26	6.7	22
26	38	172	153	123			42	4	145	31	21	9.5	26
27	33	50	75	55			36	2	155	35	27	2.6	27
28									155			3.4	28
29	50	150	133		51	74		0	158	27	19	8.0	29
31	40	140	141	110			76	4	200	29	16	5.6	31
33									250	23	20	3.3	33
34									220				34
35	34	42	25	65			48	2	220	26	18	1.5	35
40	72								250	26	23		40
41	72	186	172	91			63	0	250			6.0	41
42	46					150			155	26	18		42
43		186	211		55			3	155			9.7	43
44	88								250	29	21		44
47	97	380	233	133			88	0	110	42	34	28.0	47
49	34	230	250	155			120	0	230	31	26	8.0	49
50	49								540	21	18		50
52	50	191	183	137			79		210 ro.	31	23	7.3	52
53	57								210 sm.	33	26		53
59	86	502	640	375			235	5	610 un.	26	21	6.6	59
59									up.	42	31		59
61	59								610				61
62	57								280	26	21		62
63	60			185		139			240 un.	23	18		63
64	68	207	212					12	240 up.	29	23	7.0	64
65	60								240 ad.	65	55		65
66	30				57	127		42	240				66
67	39								132 un.	52	47		67
67									up.	70	65		67
68	47	169	180	121			75	8	220 un.	29	18	6.1	68

TABLE XI. (*Continued*).

Pl.	W.	23(s)	24(s)	30(s)	30(d)	31(s)	31(d)	N	A		B	C	D	Pl
68										up.	31	26		68
69	85	490	562		161	357		37	270		31	23	14.0	69
71	31	132	135	114			78	5	310	un.	18	16	3.4	71
71										up.	21	16		71
71										ad.	20	15		71
75	26	148	114	46			24	9	240		23	21	0.5	75
78	16	172	170	195			105	8	180		36	31	7.7	78
79	50								180				14.4	79
81	35	217	192	134			53	6	70		52	36	25.0	81
82									322		31	26	9.2	82
83	67	349	225	132			66	0	480		26	21	5.9	83
86	52	275	140						260		29	21	9.0	86
87	35	275	174						600		31	23	3.2	87
88	26	157	187		38	149		6	80		44	31	15.7	88

ro. =rough ; sm. =smooth ; un. =under ; up. =upper ; ad. =adult.
For temperature records see Table II., p. 185.
For wind velocity records see Table III., p. 186.

(9) DISCUSSION ON TRANSPIRATION AND THE RESULTS OF EXPERIMENTS.

Transpiration and the External Factors affecting it.

Temperature.—The lowest temperature recorded during days on which experiments were being conducted was 32° F. on 16/7/20, and this was the minimum temperature for the winter in the system garden. The average winter transpiration rate in the sun was very low as compared with the high summer rates. The plants with the lowest winter transpiration rates were Nos. 17, 75, and 88, each with a transpiration rate of 26; and No. 14, with 28. No. 47 had the highest transpiration rate, which was 97. The Acacias (Nos. 17-35) averaged 40, the Eucalypts (Nos. 52-71) 56, and No. 13, 43. The winter transpiration rate in the shade was exceedingly low, and that at night almost negligible. It is not intended to imply that these low rates were due to temperature only. A glance at Table II., p. 185 will show that the relative humidity was very high in winter as compared with the summer rates, e.g., 75% on 21/7/20 at 3 p.m., and 17% on 23/12/20 at 3 p.m., and this is a very important factor in regulating transpiration.

To give a clearer idea of the effects of the high summer temperatures on the transpiration rate, some of the data has been graphed (Figs. 1, 4, 6, and 7) Fortunately, it was possible to make observations on a day like 23/12/20, when the temperature rose steadily to 108° F., with only a good breeze blowing, and to compare them with those made on the following day, when the temperature rose to the same height, but with a fierce north wind blowing. It will be seen that in almost every case, the transpiration curve followed the temperature curve in proportion to the transpiration rate of the plant.

Nos. 1 and 27 (Fig. 1, p. 196), No. 78 (Fig. 4, p. 205), and No. 41 (Fig. 6, p. 215) did not follow the general rule on account of insufficient water supply.

No. 1 showed wilting of the young leaves, but soon recovered when given water. The transpiration curve of No. 41 began to decline at about 12.45, and the upper leaves began to wilt at 3.30 p.m., but when water was added they soon recovered their turgidity. Wilting usually took place almost as soon as the transpiration rate began to decline, but occasionally it did not show until much later, as in the case of No. 41.

In all records it will be noted that there are fluctuations which apparently cannot be accounted for. This has been the experience of all observers whatever methods they were using.

On 24/12/20, when the conditions were similar to those of the previous day, except that a strong wind was blowing, the transpiration curves were not so regular, for, except in a few cases, transpiration was disorganized to varying extents until the wind became less violent.

The highest transpiration records were made on 24/12/20, and were as follow:

No. 59	750	between 12 and 2 p.m.
No. 69	640	,, 12 ,, 2 p.m.
No. 13	525	,, 2 ,, 3 p.m.

The lowest records for these two days of high temperatures were as follow:

No. 35	45	on 23/12/20	(Average for the day)
No 22	60	,, 24/12/20	,, ,,
No. 17	70	,, 24/12/20	,, ,,
No. 14	135	,, 23/12/20	,, ,,

The transpiration increased very rapidly when the temperature rose above the normal, and the records show that the transpiration rates at the higher temperatures (100° to 108° F.) were from .3 to .6 times greater than those at the lower temperatures (90° to 100° F.).

Further, on 10/2/21 and on 11/2/21, the transpiration curves followed approximately the temperature curve until the water supply became inadequate.

The curves from the transpiration balance experiments (Figs. 2, 3, 5) showed also that a rise in temperature caused a rise in the transpiration rate in proportion to the rise in temperature, and according to the characteristics of the plant.

Shade.—On 31/12/20, the majority of the plants were kept in the shade all day, but, though the temperature rose 6° or 7° F. higher than on the previous day, the transpiration rates were very much lower.

Night.—In winter, transpiration during the night was practically nil, but, with the higher summer temperatures, the transpiration at night was greatly increased. This can be seen from the transpiration balance experiments and from the records of weighings made on 4/1/21 from 8 p.m. to 10 p.m. (Tables IV. to XI.).

The maximum transpiration for the day falls between 12 noon and 3 p.m.; at higher temperatures, usually after 2 p.m., and nearer 3 p.m.

The minimum transpiration rate at night usually falls between 1 a.m. and 2 a.m.; but, as shown in the curve of No. 71 (Fig. 3, p. 201) it may occur much later when conditions are abnormal.

The maximum transpiration rate, as a rule, is reached before the maximum temperature; and, soon after the maximum temperature is reached, that is, soon after 3 p.m., the transpiration curve falls very quickly; but this steep fall cannot altogether be due to the fall in temperature, as it declines more quickly than the fall in temperature. The above results agree with those of the majority of observers.

Light.—Light has a very definite effect on the transpiration rate. It has been observed that, at night, the transpiration rate, normally, is exceedingly low.

Darwin (13), by experiment on the light factor, came to the conclusion that the direct effect of light was considerable, and the transpiration rate, irrespective of the influence of the stomatal change, was as much as 36% greater in light than in darkness.

In summer, even with a minimum temperature for the night between 70° and 80° F., the transpiration rate for most plants is very low, and not comparable with that in daylight at the same temperature.

In the shade, even at temperatures between 70° and 90° F., the transpiration rate is less than .5, and in many cases only .3 of what it is in sunlight at the same temperature.

Time did not permit of any direct observations on the opening of the stomata, but the very steep rise of the transpiration curves and their sudden fall, as shown in the graphs for 23/12/20 and 24/12/20, seem to indicate that the maximum opening was reached very early in the morning, and that closure (not total), at least, in plants with high transpiration rates and at high temperatures, takes place between 4 and 5 p.m. cf. Lloyd, p. 96-97 (25) and Darwin (14).

Light, or rather, intense light also influences transpiration indirectly by causing plants that are exposed to it to modify the structure of their leaves and their position with regard to the rays of the sun. cf. Bergen (5), Schimper, p. 9 (39), Ewart, p. 447 (16).

Only four plants showed active movement of leaves in response to the intensity of light. These were Nos. 40, 45, 47, 69. The leaves of Nos. 40, 45, 47 placed themselves almost parallel to the stems. The margins of the leaves of No. 69 curled upwards and inwards. This change of position apparently did not affect the transpiration rate. Schimper, p. 9 (39), mentions that "Xerophytes with pinnate leaves have the power of automatically adjusting the transpiring leaf surface, and that the fact that they thrive alongside aphyllous plants in the driest regions proves how perfectly this arrangement works."

Acacia Baileyana (No. 35) is apparently an exception to this rule, for its bipinnate leaves do not close on to one another, nor has it special power of adjusting its leaves, yet it had the lowest transpiration rate of all the plants studied. The rest of the Acacias (Nos. 17 to 33) have phyllodia which are held, more or less, in a vertical position and in such a manner that their surfaces do not receive the full force of the sun's rays.

The Eucalypts (Nos. 52-71) were all seedlings or very young plants and their leaves were not always placed parallel to the incident rays of the midday sun, but they have other means of protection and usually they would be more or less shaded in their natural habitat. The adult leaves of most of them are placed, more or less, in the vertical position with the edges turned towards the source of light. Again, Renner (70, 71) has shown that the rate of evaporation from vertical surfaces was not appreciably affected by other evaporating surfaces if they were more than 2cm. apart; hence, the massing of the adult leaves of the Eucalypts or the phyllodia of the Acacias will not greatly affect the transpiration rate. He also found that the evaporation from a long narrow surface is greater than that of a similarly great, but more isodiametric one. This factor must play an important part in the transpiration rate of the narrow-leaved and phyllodinous plants, as compared with the broad-leaved ones.

Wind.—Wind velocities for each day on which experiments were carried out will be found on Table III., p. 186. It has been mentioned above that the wind tends to increase the transpiration rate of a plant; but an examination of the graphs on Figs. 1, 4, and 6, will show that if the velocity of the wind exceeds 15 to 20 m.p.h., the transpiration rate of many plants is disorganized—probably on account of the closing of the stomata, due to the concussion of leaves and branches. Knight, p. 133 (24), found that some stomata are sensitive to the shock produced by handling the leaf. From an examination of the data on Table II., p. 185, it will be seen that conditions, except for wind velocity, were similar on 23/12/20 and 24/12/20. From Table XI., p. 225, it will be seen that about half the plants showed an average increase in the transpiration rate for 24/12/20, as compared with the previous day, while the other half showed a decline. The same effect can be seen by an examination of the records for 8/7/20 and 9/7/20, Table IV., p. 194, and wind records on Table III., p. 186, and temperature records on Table II., p. 185.

On 8/7/20, there was a pleasant breeze averaging from 5 to 7 m.p.h., while on 9/7/20, during the time of the experiments, the wind averaged 20 m.p.h. The temperatures varied little. Nos. 1, 13, 19, 27, 59, 67, 71, 81 showed a loss in the transpiration rate, as compared with that of 8/7/20, while Nos. 14 and 49 showed an increase in the transpiration rate.

A study of the transpiration results for 9/7/20 and 24/12/20 shows that Nos. 19 and 81, both with long, narrow phyllodia or leaves suffered a lowering of the transpiration rate on very windy days, both in winter and in summer.

It will be noticed that the maximum transpiration rate is generally reached between 1 p.m. and 3 p.m., and that the transpiration curve begins to fall soon after 3 p.m., and, apparently, the rapid increase in relative humidity or decrease in evaporation rate is the main cause of the fall. cf. Schimper, p. 4 (39) and Lloyd, p. 143 (25). The evaporation rate from the free surface of water may be compared with the transpiration of plants in Table X., p. 220. The water surface used had an area of 107 sq. cm., and the surface of the water was kept at about 3 cm. below the upper edge of the vessel (Thomas and Ferguson (41)). The results were reduced to show the amount of evaporation from a sq. metre at the same rate. The figures also help to show the great difference between evaporation from a free surface of water and the transpiration from leaves.

Water supply.—All the plants studied are indigenous to districts in which the average annual rainfall is 15 inches (Nos. 34 and 35) or above 15 inches, but, as will have been noted, they vary greatly in their distribution in regard to latitude, altitude, soil, and aspects.

Altitude.—Sampson and Allen, p. 48 (38), in experimenting on the effects of altitude on transpiration, found that "the light intensity was practically constant, that the relative humidity increased with the altitude, and that the atmospheric pressure decreased." The above results were corroborated by Clements (1), and they show that, other things being equal, an increase in altitude stimulates an increased transpiration. This acceleration is not due to increased light intensity and a lower air humidity, but is due to decreased pressure. cf. Schimper, p. 4 (39). One of the most interesting plants studied came under this heading, namely, No. 68, the habitat of which is confined to a few of the peaks in the Grampians mountains, and it has been shown that it is protected from excessive transpiration in many ways, and in both juvenile and adult stages. Plate XIII. Fig. 2.

Transpiration and Internal Factors affecting it.

Time has not permitted the examination of the internal structure of the leaves, except in a few cases such as Nos. 13, 67, 81, and 82, where it was necessary to section the leaf in order to obtain the correct idea of the structure and number of the stomata.

Stomata.—Brown and Escombe (7 and 8), working with the leaves of *Helianthus*, and Lloyd, p. 32-39 (25), with the leaves of *Fouquieria splendens*, showed that the diffusion capacity from a leaf was six times greater than the transpiration rate. Hence, transpiration rates may not be related within wide limits to the dimensions of the stomata; so that increases and decreases in the transpiration rate may occur without being due to stomatal movements.

Number of stomata.—An examination of Table XI., p. 225, will show that the number of stomata per sq. mm. of transpiring surface ranges from 70 (No. 81) and 80 (No. 88) to 500 (No. 13), 540 (No. 50), 600 (No. 87), 610 (No. 59), and very few have less than 150 per sq. mm., so that, though the epidermis in many cases is exceedingly thick, adequate arrangements are made for the movements of gases through it; and, where the number of stomata is very high, the transpiration rate is high. The highest records of stomata per sq. mm. are: 1030, 970, 960 on some leaves of Nos. 63 and 64; 740 on some leaves of No. 59.

There are very few records of plants with the number of stomata above 500 per sq. mm., and the average number of stomata of the plants studied is relatively high. cf. Morren (30), Tschirch (42), Kerner and Oliver (22), and others.

Sizes of stomata.—These are tabulated in Table XI., p. 225, and range from 52 x 36 micra (No. 81), 70 x 65 micra (No. 67), to 18 x 16 micra (No. 71). No. 81, with stomata 52 x 36 micra, has only 70 per sq. mm., but its transpiration rate is well above the average.

No. 88, with stomata 44 x 31 micra, has 80 stomata per sq. mm., but its transpiration rate is not quite so high as that of No. 81.

No. 47, with stomata 42 x 34 micra, has 110 stomata per sq. mm. on its small leaves, and its transpiration rate is high.

No. 71, with stomata 18 x 16 micra on the under side and 21 x 16 micra on the upper side, has an average of 310 stomata per sq. mm., but its transpiration rate is comparatively low.

The size of the stomata in the Acacias (Nos. 17 to 35) does not vary much, but the same cannot be said of the Eucalypts (Nos. 52 to 71). Illustrations of the stomata will be found on Plates XIII. to XVIII. The figures bear the register number of the plant they represent.

Stomata and epidermal cells.—Copeland, 359 (12), states: "The size of the stoma usually corresponds somewhat to that of the epidermal cells (Salvinia is a conspicuous exception) and the mechanism of the stoma must be correlated with the size, and the depth, and the thickness of the walls of the neighbouring cells." He shows that this must affect the method by which the guard cells move. Most of the plants studied follow this rule, but exceptions will be found in the adult form of many Eucalypts, e.g., No. 64, (Plate XVI., Nos. 64, 64 (a) and 64 (c); No. 67, (Plates XVI. and XVII., Nos. 67 (b) and 67 (d)) where the stomata are much larger than the epidermal cells; and Nos. 47, 78, and 88 (Plates XV., XVII., and XVIII., respectively) in which the size of the stomata is much less than that of the epidermal cells. In most of the plants studied, there are no special structures for protecting the stomata beyond the cuticularization of the outer edges of the guard cells.

Special protective structures prevent excessive transpiration, but, apparently, do not regulate it.

The plants, having special methods of protecting the stomata, are among the most interesting studied.

Hakea gibbosa (No. 81) has the same type of protection as *H. suaveolens* and *H. cyclocarpa* as figured by Tschirch (42).

Plate XVII., No. 81 and Plate XVIII., No. 81 (b).

Myoporum insulare (No. 88) has the stomata raised above the surface of the epidermis, and, though the leaf appears dorsiventral, the structure of both sides is practically the same.

Casuarina Luehmanni (No. 13), with its slender, stringlike branchlets, armoured with a thick cuticle and strengthened by a very large percentage of sclerenchymatous tissue, with its stomata hidden away in fairly thin-walled grooves, which are protected from the direct action of wind, sun and dust by lines of branched hairs, has a winter transpiration rate about the average; but its summer rate is the third highest of the plants studied. High temperatures and strong winds do not affect this plant so long as it can obtain water, but if the supply runs short the transpiration rate falls and the young shoots wilt, but the old branchlets are able to withstand a reduced water supply, and are ready to continue their work when a supply of water becomes available. The transpiration rate responds quickly to changes in temperature, wind velocity, and water supply. Hence, the plant can make the best use of sudden increases in water supply, especially at high temperatures.

Banksia serrata (No. 82).—The structure has been described by Hamilton (20). This plant has its stomata hidden in a somewhat different manner from No. 13, and, as it lives mainly along the coast, has some of the characteristics of a halophyte (Schimper, pp. 88 and 530-534, Fig. 297 (39)), yet its number of stomata is above the average and its transpiration rate is also above the average; but it does not seem to have the same control over the transpiration rate that No. 13 has.

The Eucalypts formed interesting studies, especially as all specimens experimented with had juvenile leaves, except No. 67.

From seedling to adult stage the leaves take 2 or 3 different forms, and in each stage the number of stomata and their size usually differ, as also does the method of protection. The transpiration rates of Nos. 59 and 69 were above the average, but those of the remainder were about the same as those of the Acacias.

Acacias.—The Acacias vary very little in their external arrangements for transpiration and protection from drought. All of them, except No. 19, favour dry localities, and it will be noted that No. 19 has a high average number of stomata per sq. mm. for an Acacia, and that they are the largest.

Acacia Baileyana, which was the only non-phyllodinous Acacia used, gave the lowest transpiration results.

Ficus macrophylla (No. 14) is one of the best drought resisting forms tested. It has stomata on the under surface only and the number is fairly low (120), but with its thick epidermis varnished on the upper surface, it seems to have good control of its transpiration rate. The high velocity of the wind on 23/12/20 made a greater impression on the transpiration rate than did the high temperature.

Transpiration per million stomata.—On Table XI., p. 225, will be found the average transpiration rate per million stomata per hour for 8 hours of daylight on 23/12/20, and a study of them gives some idea of the effect of the number and size of stomata on the transpiration rates of the plants used.

It is interesting that *Pimelea flava* (No. 47), the plant with the smallest leaves, should have the highest transpiration rate: 28 per million stomata. Its stomata are large, but their number is below the average.

Acacia linearis (No. 19).—The Acacia with the highest average for the species, is the one which favours moist localities.

Hakea gibbosa (No. 81).—*Hakea gibbosa* has the second highest average, which is 25. Its needle-like leaves have large stomata, but the number is much below that of No. 47, and its transpiration rate does not differ much from that of No. 47, except at high temperatures, when that of No. 81 is much lower.

The lowest rates are shown by Nos. 75, 33, 71, and 17, and are 0.5, 3.3, 3.4, and 3.5 respectively. These also have the smallest stomata and the number per sq. mm. is not relatively high.

No. 13, with its great range of transpiration rate from winter to summer, and from low temperatures to high temperatures, has a very low average rate per million stomata, but for the size of the area of its transpiring surface, it has a high number of stomata.

A comparison of the transpiration rates per million stomata with the transpiration rates for the areas, emphasizes the facts that the size of the stomata is an important factor in influencing the number of stomata on leaves and the transpiration rate of plants, although the stomata may not have a very great regulatory effect on the absolute transpiration of the plant.

The size of the stomatal aperture has long been recognised as a factor concerned in the regulation of the rate of transpiration, but the extent to which this regulatory function is shared by the stomata with other internal conditions of the plant has not yet been settled.

It is certain that in plants, especially like those of the Acacias (Nos. 17-35) that there must be some important factor, other than that of the opening and closing of the stomata, regulating the supply of water to the foliage, and so regulating, to a great extent, the transpiration rate.

Probably a study of the structure of the stems or roots of the Australian xerophytic plants may help us to realize more fully the manner in which these plants with their relatively high number of stomata of comparatively large size, are able to overcome the extremes of temperature and of water supply. cf. Cannon (9); Ewart and Rees, p. 97 (5); Farmer (17); Richardson (37).

(10) Conclusions.

The main object of this work was to endeavour to discover whether Australian plants, especially those with xerophytic characters, which, in their native state, are able to thrive under adverse conditions of temperature and water supply, have any special powers of accommodation, such as a regulatory decrease in transpiration, when exposed to such enormous rises in temperature and evaporation as are caused by the hot north wind. cf. Ewart and Rees (15).

The results of the experiments show that, so long as the available water supply is adequate, the plants have no special powers of accommodation as mentioned above, for, as the temperature rises, the transpiration rate increases to the limit of the transpiring power of the plant for that temperature.

Some plants have their transpiration checked when the velocity of the wind rises to about 20 miles per hour.

The phyllodia of the Acacias, from their shape and position on the plant, their large or comparatively large, number of stomata with the thick cuticle to protect them from intense light, heat, and wind, are perfect transpiring organs, and the plants have a relatively high transpiration rate, yet they are found chiefly on xerophytic plants, indigenous to Australia: with the phyllodia must be associated the leaves of the Eucalypts.

The so-called xerophytic plants of Australia are provided with a high average number of stomata, which enables their transpiration rate to respond quickly to changes of temperature and water supply, and they are well protected by their tough outer coverings, in some cases assisted by glands, from injurious loss of water.

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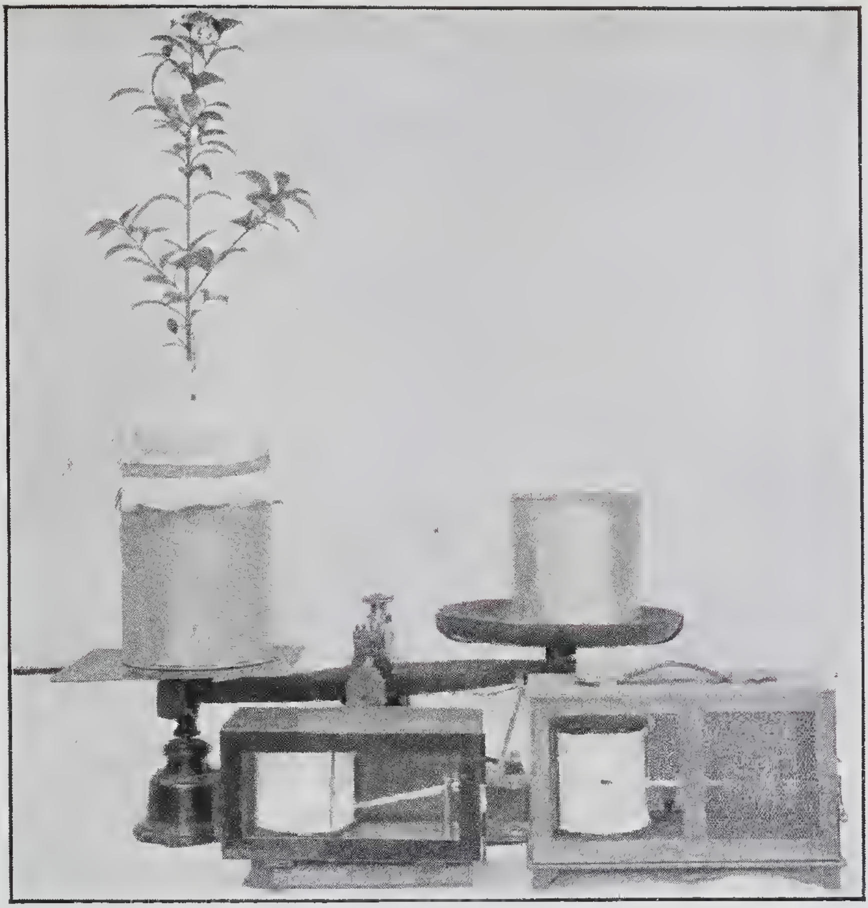

Fig. 1

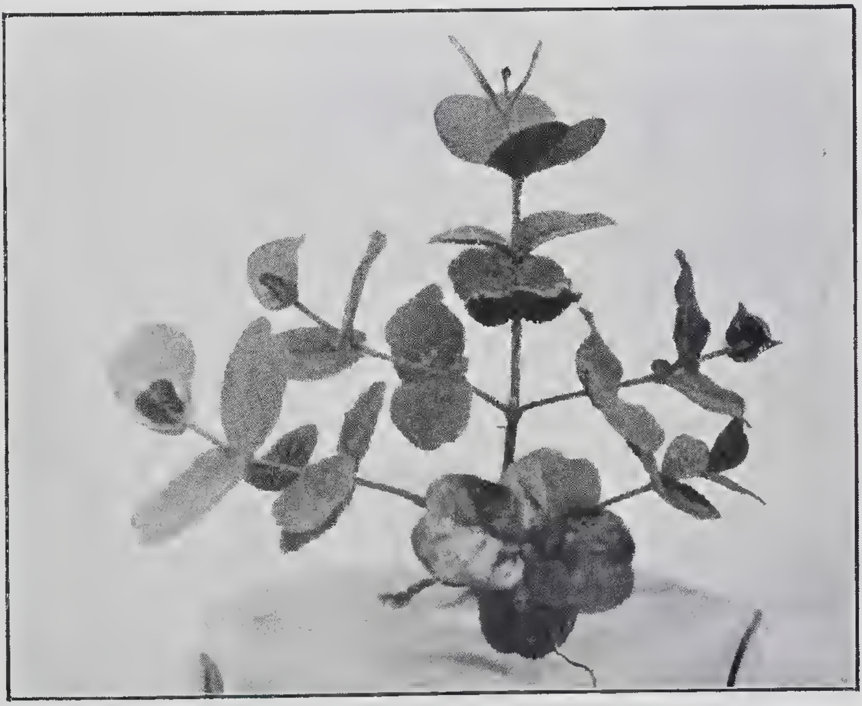

Fig. 2

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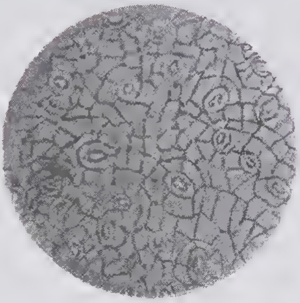

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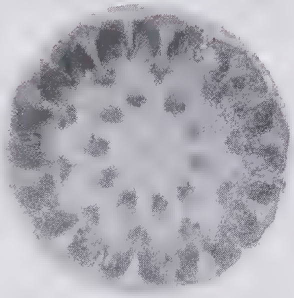

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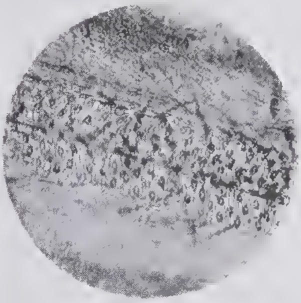
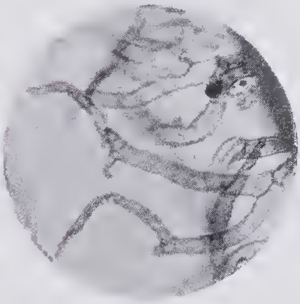


13(a) x45

13(b) x 110



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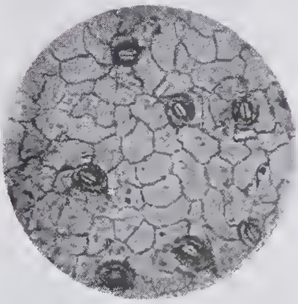

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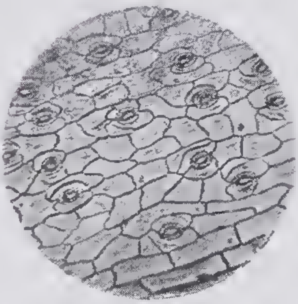

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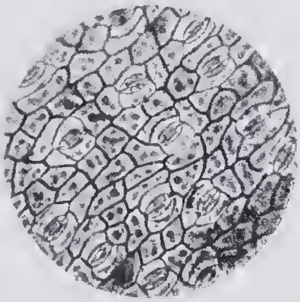

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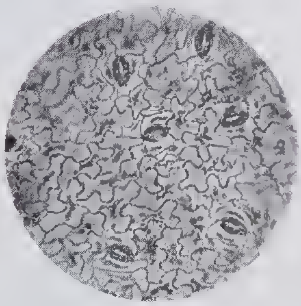

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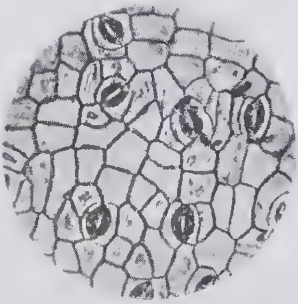

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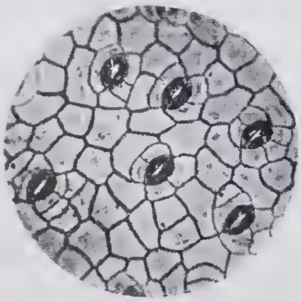

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